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Meteorological Analysis of Precipitation Event Sampling Data (July 1980 - December 1981)

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Ontario Ministry of the Environment

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Meteorological Analysis

of

Precipitation Event Sampling Data

(July 1980 - December 1981)

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Summary

This report describes the trajectory analysis of 18 months of precipitation data collected at locations in southwestern, central and eastern Ontario. The purpose of the trajectory analysis was to relate the wet deposition of various chemical species to octant of airmass origin.

The results for several chemical species and for different trajectory lengths were determined. (As an example see Table 2 for Dorset - 24 hour trajectory analysis). Despite some sources of error relating both to the data itself and to the analysis procedure, we may conclude that southerly to westerly airflows are associated with at least 50% of the wet deposition of sulphate and nitrate in Ontario. The loading contributions vary somewhat according to location and according to length of trajectory (in hours). Mean event loadings are also highest for airflows between south and west.

Southwesterly air reaching southern and central Ontario has passed over the industrialized Ohio Valley which is heavy in sulphur and nitrogen oxide emissions, and has often passed over industrial regions of southwestern Ontario as well. Such air is generally associated with more precipitation than air from other directions for synoptic meteorological reasons, and this only exacerbates the wet deposition problem for Ontario.

The trajectory analysis work is continuing and the statistics are continually being updated. Analysis of data collected at event precipitation sites in northwestern Ontario will be included in the next phase.

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I. Introduction

1. Basis of Analysis

This work was launched in an attempt to estimate the contributions to precipitation loadings in Ontario from the various compass sectors through the use of air parcel trajectories. The uncertainties associated with single trajectories are well-documented and we have attempted to minimize the effects of such errors by utilizing a statistical approach. The directional distribution of trajectories of different time lengths have been studied along with the mean and total pollutant loadings associated with the various sectors. In order to roughly define an error bound, we provide comparative statistics for trajectories of two types: 1) surface geostrophic (based on surface pressures) and 2) 850 mb (based on the height of the 850 millibar surface). The first trajectory reflects the flow at about 800 m above the surface and the second is based on wind patterns at about 1500 m elevation.

We include here an analysis of data collected over the period July 1980 to December 1981 in 3 regions of Ontario. References in this report to Dorset, London and Kingston without further qualification refer to stations 8,2 and 10 (see Figure 1) respectively, as these are the primary stations in their respective clusters.

2. Methodology

The two components of the data set are: (1) the precipitation chemistry data, and (2) the meteorological data. The chemistry data utilized for this study include measured daily concentrations and loadings for each of H^+, $SO_4^=$, NO_3^{-*}, Cl^-, Na^+, K^+, NH_4^{+*}, Ca^{++} and Mg^{++} in precipitation, as determined from wet-only samplers at the sampler locations indicated in Figure 1. (A discussion of the data collection, appears in Chan et al., 1982). The meteorological data are derived from the Ministry of the Environment Meteorological Data Acquisition System (MDAS) and consist of 6,12,18,24,30,36,42 and 48 hour back-trajectories from each of the event sampling sites (Figure 1). These are computed at

* Note that nitrate and ammonia ion concentrations are reported throughout this study in terms of nitrogen.

the "synoptic times" (00GMT, 06GMT, 12GMT, 18GMT) for as long as the precipitation persists. If the precipitation lasts less than 6 hours, the closest synoptic time is chosen for the trajectory. When time of precipitation occurrence is not known precisely, the assumption is made that the precipitation covered the entire 24-hour period i.e., 4 back-trajectories are computed.

The trajectories are horizontal i.e. no vertical air motions have been incorporated. Computations are done on the Air Resources Branch Data General Eclipse Computer which receives hourly weather observations from over 400 North American surface and upper air stations. Two types of trajectories are calculated. The "modified surface geostrophic trajectory" is based on the mean sea level pressure geostrophic wind field where direction is "backed" (i.e. turned anti-clockwise) by 15^{o} and the speed reduced by 10% in order to account for surface frictional effects. The 850 mb trajectory is based on the gradient wind as computed from the height field at the 850 millibar pressure level. The method of generating trajectories from pressure or height fields is as described, for example, by Pettersen (1956). One or the other approach may be more relevant to a particular situation. However, the two sets of statistics give two different estimates of the sector distribution for the origin of the various chemical species in precipitation. The end-points of each of the back-trajectories are classified according to "sector of origin", each sector being 45^{o} in width and centered on one of the eight points of the compass (N, NE, E, SE, S, SW, W, NW). In summary, then, for each 6 hours of precipitation (or less) there is an associated set (6,12,18,24,30,36,42,48 hour) of modified surface geostrophic back-trajectories and a set (12,24,36,48 hour) of 850 mb back-trajectories.

For each 24 hour period during which precipitation occurred there exists precipitation chemistry data which almost always include precipitation gauge depth and concentrations of H^{+}, $SO_4^{=}$ NO_3^{-} and Cl^{-} and usually include concentrations of Na^{+}, K^{+}, NH_4^{+}, Ca^{++} and Mg^{++}.

The method described below was applied generally to all trajectory lengths (6 to 48 hours) and to both trajectory types.

The aim of the analysis was to generate trajectory statistics for the precipitation chemisty data. Initially, each event was associated with a particular sector of trajectory origin. When a single trajectory existed for a particular event, the sector of origin was the compass sector in which the trajectory found itself for the prescribed trajectory length. When there existed more than a single trajectory, the event was placed in the unknown sector unless at least 50% of the trajectory end-points were within the same compass sector. Also included in the unknown sector were events for which: the trajectory left the region of meteorological data coverage; meteorological data were missing; or the back-trajectory end-point was very close to the receptor. When precipitation amount or concentration data were missing the event was entirely excluded from the analysis.

The end-result of the computer analysis of precipitation chemistry and trajectory information were tables of the type displayed in Table 1. The example is for $SO_4^=$ and is based on 24-hour modified geostrophic back-trajectories from Dorset. Similar tables were derived for each pollutant species, for each trajectory type and length, and for each station in each cluster. All of this information is too voluminous for presentation and for discussion. Instead, summary tables have been derived and the results for sulphate and nitrate are stressed. The summary tables, however, do include concentration and loading information for several other chemical species.

II Dorset Loading Analysis

1. Surface Geostrophic Trajectory Analysis

The Dorset analysis is based on the chemistry data collected at Station 8 (see Figure 1). The 24 hour geostrophic trajectory

analysis is summarized in Table 2 where it can be seen, beginning from the top left of the Table, that 3% of the 18-month H^+ loading was associated with the north sector, 8% was associated with the north east sector and so on. The totals are close to 100% with deviations being due to round-off. The unknown class includes trajectories that have gone beyond the range of meteorological data coverage* of MDAS (the Meteorological Data Acquistion System). N (in the bottom row) is the total number of chemically analyzed precipitation samples included in the statistical analysis. Due to frequently high percentages in the "unknown" class all percentage loadings should be interpreted as lower limits. Particularly when the "unknown" contribution is substantial, the contributions from the various sectors are more than would be indicated by the Table entries.

It will be seen that 52% of the total gauge depth (or precipitation amount) was associated with S or SW, while over 60% of the sulphate and nitrate was associated with these sectors. The 48-hour geostrophic trajectory analysis (Table 3) had the $SO_4^=$ and NO_3^- loadings concentrated in the 4 sectors between SE and W with totals of 59% and 61% for sulphate and nitrate respectively. The gauge depth total for these sectors was 52%. Sulphate and nitrate loadings for the unknown class were around 20% as was the gauge depth. Note that 45% of the Na^+ loading was in the unknown class. This is apparently due to the long (high wind speed) trajectories which imply a higher probability of wind-blown salt from roads landing in the precipitation collector. An examination of the individual data points showed that high Na^+ values during high wind conditions are contemporaneous with high Cl^- values.

2. 850 mb Trajectory Analysis

Table 4 shows the sector distribution of loadings based on 850 mb trajectories. 45% of the precipitation was associated with W or SW, while the percentage of loadings for sulphate was 51% and nitrate 56%. Approximately 30% was associated with the "unknown" sector for these two species. The clockwise shift of emphasis from S and SW for surface geostrophic trajectories to W and SW for 850 mb trajectories is a reflection of the typical "veering" or clockwise swing of the winds from lower to higher altitudes.

* The western limit of meteorological data coverage is the Rockies; the southern limit is approximately 30° N latitude.

The statistics for 48 hour back-trajectories (Table 5) are quite similar to the 24-hour statistics. W and SW account for 46% of the precipitation and about 50% of sulphate and nitrate loadings.

3. Variance Among Sites

The station locations for the Dorset cluster are shown in Figure 1. It will be seen that stations 5 and 6 lie in close proximity as do stations 7 and 8. However, these 2 groups are separated by about 70 km. It is interesting to compare the trajectory statistics from the different stations. Surface geostrophic trajectory analysis (24-hour) was perfomed independently for $SO_4^=$ loading data collected at the each of the sites, and the results are summarized in Table 6. The sector distributions for stations 7 and 8 are similar. However, the distributions for stations 5 and 6 appear dissimilar. This is primarily due to the fact that the period of coverage and the total sample sizes differ.

4. Variance Due to Trajectory Length

Table 7 compares $SO_4^=$ loading statistics based on different trajectory lengths. The sector distributions do not change appreciably for back-trajectories ranging from 6 hours to 42 hours. Interestingly, however, an abrupt change occurs at 48 hours. This appears to be due to a combination of: trajectories going out of bounds; and an increased spread in the trajectory end-points.

III London Loading Analysis

1. Surface Geostrophic Trajectory Analysis

The 24-hour London loading analysis was based on precipitation data collected at Station 2. Table 8 shows that the precipitation occurred over a wider range of back-trajectory sectors than was the case at Dorset. SW was the predominant sector for each of sulphate, nitrate and gauge depth, but SE appeared most important for hydrogen ion.

For 48-hour trajectories (Table 9), the SW sector was most important, but the NW sector followed closely behind. The importance of the northwest sector to pollutant loadings at London follows from the high frequency of moisture laden northwesterly flows off Lake Huron, particularly in winter. The greater frequency of precipitation during northwesterly winds naturally leads to higher precipitation loadings associated with the NW sector at London.

2. 850 mb Trajectory Analysis

Based on 850 mb trajectories (Tables 10 and 11), the 24 hour and 48 hour statistics are quite similar. Approximately 60% of the precipitation, sulphate loading, and nitrate loading were associated with the west or southwest sectors.

IV. Kingston Loading Analysis

1. Surface Geostrophic Trajectory Analysis

The Kingston loading analysis was based on precipitation data collected at Station 10. Table 12 shows that 55% of the precipitation and over 60% of the sulphate and nitrate loadings apparently came from the south and southwest.

For the 48-hour trajectories (Table 13), there occurs a shift to the west with W and SW combined accounting for 56-57% of the loadings of sulphate, nitrate and total gauge depth.

The "zero loadings" from the southeast sector, according to Table 13 are very interesting. They are corroborated by Table 15 which shows "zero loadings" according to the 850 mb analysis as well. The implication is that although pollution sources to the southeast contribute about 10-15% of pollutant loadings to central and southwestern Ontario, the same is not true for eastern Ontario.

It should also be noted that southwesterly airflows, which at Kingston are associated with the most significant wet deposition of sulphate and nitrate, implicate pollutant sources in the United States (and sometimes southwestern Ontario sources as well).

2. 850 mb Trajectory Analsyis

The 850 mb 24-hour statistics (Table 14) show a greater influence of the southerly sector than do the London or Dorset statistics. This is partially a reflection of higher precipitation amounts during southerly flows at Kingston. Table 15 demonstrates that 50% of the precipitation and about 50% of both sulphate and nitrate loadings were linked to the westerly or southwesterly sectors for 48-hour trajectories.

V. Mean and Total Loadings by Sector

Figures 2 through 17 depict mean precipitation loadings and total precipitation loadings by sector, for various chemical species, for each of Dorset (Station 8), London (Station 2) and Kingston (Station 10) for the 18-month period of study. In each Figure, the Dorset result is the most northerly (near the top of the page), the London result the most westerly (left side of the page) and the Kingston result the most easterly (right side of page).

Figure 2 shows mean precipitation loadings for sulphate. Examining the Dorset sector loadings we can see that the units (bottom left of box) are mg/m^2. We also see that 11.0% of the data are not included in this statistic (i.e. meteorological data missing or incomplete), that the analysis is based on the 24-hour modified surface geostrophic back-trajectories, that the period included is July 15, 1980 to January 1, 1982, and that the chemistry data are derived from precipitation collected at Location 8 (Dorset -see Figure 1). The mean precipitation loading for a particular sector is the total loading for the sector divided by the number of precipitation events in that sector. Figure 2 shows that the average precipitation event from the south results in the deposition of 44 mg/m^2 of sulphate while the average event from the north results in a deposition of only 5 mg/m^2 of sulphate.

Figure 18 (which is discussed in Section VI) shows the mean distances associated with the 24-hour back trajectories from Dorset. Southerly trajectories are, on average, 560 km long while northerly trajectories average 670 km length. This information puts source contribution into perspective. Specifically, for the analysis based on the 24-hour modified surface geostrophic back-trajectories, source regions in the order of 600-700 km distance are implicated. Further, for the analysis based on 48 hour modified surface geostrophic back-trajectories, source regions around 800-900 km distant (see Figure 18b) would be important. Specific reference to source regions will not be extensive in this report. After 5 years of precipitation data have been analyzed, such a discussion would be more appropriate.

While the highest mean sulphate loading at Dorset occurred with trajectories from the south, the London sulphate loadings peaked in the east and southeast, probably reflecting pollutant emissions of the Toronto-Hamilton region. Air from the north appeared to be the cleanest, with a loading value of only 9 mg/m^2 per precipitation event.

The mean precipitation loadings for Kingston peak in the south and southwest where U.S. sources, and often southwestern Ontario sources, can be implicated. The maximum precipitation loading of 47 mg/m^2 was associated with trajectories from the south.

Figure 3 demonstrates total precipitation loadings by sector for sulphate. Although means may be of scientific interest, the total loadings generally relate to environmental effects. It will be seen from Figure 3 that the total wet deposition of sulphate at Dorset was highest from the southerly sector at 1400 mg/m^2. Southwesterly was the dominant sector at London and Kingston with contributions of 1300 mg/m^2 at London and 1700 mg/m^2 at Kingston. Total precipitation loadings were lowest for the sectors around north (0-300 mg/m^2), and for the easterly sector with which very few events were associated.

The differences in the directional distributions (Figures 2 and 3) are due to synoptic causes, specifically, the fact that precipitation is most frequently associated with south or southwesterly flows. Although pollution is imported by winds of every direction, wet deposition in Ontario is most heavily influenced by winds of south and southwesterly origin as these are the prevailing winds during precipitation. Unfortunately for Ontario, south and southwest are also the directions of the highest emissions of sulphur and nitrogen oxides.

The nitrate results were qualitatively similar to sulphate. The highest mean precipitation loadings (Figure 4) are 5.8 mg/m^2 from the south at Dorset, 8.4 mg/m^2 from the east at London, and 7.3 mg/m^2 from the south at Kingston. Total precipitation loadings (Figure 5) were lowest in the sectors around north (20-40 mg/m^2) and highest in the southwest (180-270 mg/m^2).

Similar statistics for other chemical species found in precipitation are depicted in Figures 6 through 17. These will not be discussed here, however, perusal of the figures will reveal some interesting differences in sector distribution of loadings, which reflect both species and geographic differences.

VI. Mean Trajectory Length by Sector

The importance of the mean lengths of the back-trajectories was alluded to in Section V. In discussing contributions from various sectors, the mean length of trajectories provides some quantification of the distance to the relevant source regions. In Section V, the mean and total loadings by sector were determined through the use of 24-hour trajectories. Should some other period have been used, e.g. 6 hour or 48 hour back-trajectories, the result may have been quite different. This Section simply provides some statistics of the 6 to 48 hour modified surface geostrophic back-trajectories from Dorset and a comparison of trajectory statistics at the 3 event cluster locations.

In the trajectory analyses for the various ionic species, trajectories were computed for each precipitation period for which chemical analysis for the particular species was carried out. For example, for the sulphate analysis, a set of trajectories was generated corresponding to the sulphate data available. Needless to say, some differences exist between the trajectory set generated for the sulphate analysis and those for other (e.g. nitrate) analyses. For the mean trajectory length computations, the back-trajectories of the sulphate analysis were utilized, and this is why $SO_4^=$ is mentioned in the various legends of Figure 18. The legend also provides the multiplicative factor (e.g. x 10 km) for the numbers displayed in the Figure. Thus, for example, the mean trajectory length for 6 hour trajectories from the south was 23 x 10 km or 230 km. For the 6 hour trajectories (as labelled in the legend), 11.5% of the trajectory data were missing, mainly due to missing or incomplete meteorological data. The period of data collection July 15, 1980 to January 1, 1982, and the location (as per Figure 1) are also provided. The Figure 18 statistics all apply to Location 8 - Dorset.

Figure 18 covers two pages with the 6 to 24 hour statistics in Figure 18a and the 30 to 48 hour statistics in Figure 18b. Mean back-trajectory lengths vary from around 200 km for 6 hour trajectories to about 800 km for 48 hour trajectories. In general, the lengths of trajectories in the easterly sector are the shortest due to the relatively short persistence of easterly winds.

Figure 19 provides a comparison betwen 24-hour back-trajectory lengths computed at the 3 event clusters, with, Raven Lake (Dorset cluster Station 5) at the top, London (Station 2) to the left and Kingston (Station 10) to the right. The differences are mostly due to the different number of events and the different times of events at the various locations.

VII Discussion and Conclusion

As a result of this analysis of 18 months (July 1980 to December 1981), of precipitation data, we may conclude that by far, most of the sulphate and nitrate loading is associated with southerly to westerly air flows into Ontario. In large part, this is due to the fact that most of the precipitation that falls in Ontario is associated with southerly to westerly winds. But the acidic precipitation problem is further exacerbated by the fact that southerly air reaching southern and central Ontario has passed over the industrialized Ohio Valley which is rich in sulphur and nitrogen oxide emissions, and has often passed over industrial portions of southwestern Ontario as well.

Notwithstanding this conclusion, the quantification of the contributions from the various sectors cannot be considered precise, for several reasons. First, trajectories have inherent errors resulting from their computation. Additionally, the representation of the air flow by a single trajectory, when in effect precipitation often occurs with inflow from several directions, may often lead to erroneous results.

The relatively small size of the precipitation event data set is another source of error. When the data set is small, individual events have large effects on the total loadings, and the derived statistics may be atypical. It is difficult to state the length of collection period that would be considered "statistically representative". From a meteorological standpoint, an absolute minimum of five years is required for any type of climatology, while the period used for this study was 18 months. The number of events included in the analysis for the various chemical species at the various locations is summarized in Tables 16,17, and 18. As a result of some of the low numbers appearing in these tables, there occur anomalies which should gradually disappear as the data bank grows.

Since the period of study begins in Summer 1980 and ends in Fall 1981 we have a seasonal bias resulting from the inclusion of two

summers and two autumns but only one winter and one spring. The effect of this bias may be to somewhat overemphasize the frequency of southwesterly airflows, and underestimate the northwesterly ones.

Despite the sources of error, some conclusions do stand out. Of particular relevance is the 24-hour back-trajectory analysis (Figures 2,8 and 12) with mean trajectory lengths of 600-700 km (roughly the distance from south-central Ontario to the industrialized Ohio Valley region). Both the surface geostrophic and the 850 mb analyses point to the southwest sector as a major air mass source for high sulphate and nitrate loadings in precipitation. Further quantification of this result will continue as the analysis proceeds.

Mean precipitation event loadings also show a preference for the southerly sector but the effect is not as pronounced as for total loadings. Further work will also include an analysis of the Northwestern Ontario event data. Some additional statistical treatment of the results is also planned.

AQM21-22

VIII References

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Table 1

An example of the output of the Trajectory Sector Analysis

SECTOR ANALYSIS

SO4 --mg/l

SECTOR	N	MINIMUM CONC. mg/l	MAXIMUM CONC. mg/l	MEAN CONC. mg/l	STD. DEV. OF CONC. mg/l	TOTAL GAUGE DEPTH mm
N	20	.050	7.000	1.925	1.625	58.8
NE	12	.200	25.700	3.937	6.934	170.2
E	6	.150	10.000	4.867	4.589	34.7
SE	17	.300	8.650	3.097	2.315	164.6
S	32	.300	19.900	4.303	4.017	412.4
SW	46	.350	15.000	3.964	2.923	357.5
W	21	.750	8.000	2.288	1.851	119.1
NW	8	.500	5.400	1.969	1.656	18.3
UNKNOWN	20	.200	11.400	2.620	2.640	133.9
SUMMARY	182	.050	25.700	3.318	3.349	1469.5

SECTOR	MINIMUM LOADING mg/m^2	MAXIMUM LOADING mg/m^2	TOTAL LOADING mg/m^2	MEAN LOADING mg/m^2	STD. DEV. OF LOADING mg/m^2
N	.075	20.060	104.575	5.229	5.527
NE	.380	126.100	313.340	26.112	34.401
E	.930	158.650	192.200	32.033	62.251
SE	1.500	173.000	502.805	29.577	43.957
S	1.120	185.760	1411.955	44.124	42.693
SW	2.400	132.000	1205.650	26.210	25.254
W	.660	43.700	224.420	10.687	10.289
NW	.770	12.900	30.225	3.778	3.991
UNKNOWN	.640	48.530	246.845	12.342	13.017
SUMMARY	.075	185.760	4232.015	23.253	32.001

TABLE 2

Sector Distribution of loadings based on modified surface geostrophic 24 hour back trajectories from Dorset. Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^{++}	Mg^{++}	Gauge Depth
N	3	2	3	3	4	3	2	3	2	4
NE	8	7	7	6	8	6	8	6	5	12
E	4	5	4	4	1	1	3	3	2	2
SE	13	12	9	9	9	6	7	5	5	11
S	39	33	30	26	14	22	30	20	21	28
SW	22	28	33	36	45	45	34	46	49	24
W	5	5	7	7	5	8	7	9	7	8
NW	1	1	1	1	1	0	1	0	1	1
UNKNOWN	6	6	7	7	12	8	8	9	8	9
Total	101%	99%	101%	99%	99%	99%	100%	100%	100%	99%
N	184	182	183	183	157	157	155	154	153	198

TABLE 3

Sector Distribution of loadings based on modified surface geostrophic 48 hour back trajectories from Dorset. Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^{++}	Mg^{++}	Gauge Depth
N	7	6	6	5	6	6	9	5	5	12
NE	6	7	5	6	6	3	4	4	3	4
E	3	3	4	3	3	2	2	4	3	5
SE	18	16	11	11	8	7	11	7	6	12
S	15	13	12	10	9	9	10	8	10	9
SW	19	18	24	26	14	18	22	28	25	21
W	8	12	14	12	7	27	12	16	16	10
NW	5	3	4	3	2	4	3	2	2	5
UNKNOWN	20	21	20	25	45	23	27	27	29	21
Total	101%	99%	100%	101%	100%	99%	100%	101%	99%	99%
N	184	182	183	183	157	157	155	154	153	198

TABLE 4

Sector Distribution of loadings based on 850 mb 24 hour back trajectories from Dorset.
Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^{++}	Mg^{++}	Gauge Depth
N	2	2	3	2	2	1	2	2	1	2
NE	1	1	0	2	4	1	0	1	1	2
E	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	1	2	0	0	0	1	* 0
S	10	9	7	9	6	5	6	3	4	9
SW	36	35	34	35	47	31	37	38	40	28
W	14	16	22	23	13	34	19	25	23	17
NW	3	5	6	5	5	7	8	11	10	6
UNKNOWN	33	32	27	23	21	20	29	21	21	35
Total	99%	100%	99%	100%	100%	99%	101%	101%	101%	99%
N	184	182	183	183	157	157	155	154	153	198

* Due to round-off error.

TABLE 5

Sector Distributions of loadings based on 850 mb 48 hour back trajectories from Dorset.
Fnteries are percentages of total Loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^{++}	Mg^{++}	Gauge Depth
N	1	1	1	1	1	1	1	1	1	1
NE	0	0	0	0	0	0	0	0	0	0
E	0	0	0	2	3	0	0	0	0	1
SE	1	0	0	1	2	1	0	0	1	1
S	3	3	2	2	2	3	2	1	2	3
SW	40	37	33	28	24	26	35	27	27	28
W	14	12	19	21	9	15	17	19	18	18
NW	4	5	7	5	6	8	8	11	11	7
UNKNOWN	37	42	37	39	53	47	38	40	41	42
Total	100%	100%	99%	99%	100%	101%	101%	99%	101%	101%
N	184	182	183	183	157	157	155	154	153	198

TABLE 6

Comparison of Sector Distribution of loadings for $SO_4^=$ as obtained from 4 stations in the Dorset cluster. Entries are percentages of total loadings.

	#5	#6	#7	#8
N	2	2	5	2
NE	3	2	1	7
E	1	1	1	5
SE	15	12	12	12
S	19	37	35	33
SW	46	39	30	28
W	2	3	6	5
NW	1	0	2	1
UNKNOWN	11	3	9	6
Total	100%	99%	101%	99%
No.	103	88	107	182

Table 7

Comparison of Sector Distribution of $SO_4^=$ loadings at Dorset(Station 8) for different trajectory lengths.
Entries are percentages of total loadings.

	t-6	t-12	t-18	t-24	t-30	t-36	t-42	t-48
N	5	5	4	2	4	6	6	6
NE	4	5	6	7	6	6	5	7
E	4	4	1	5	6	3	3	3
SE	14	14	17	12	12	12	13	16
S	29	30	32	33	31	28	25	13
SW	28	32	30	28	27	26	26	18
W	7	5	5	5	4	5	7	12
NW	3	1	1	1	1	2	2	3
UNKNOWN	5	4	5	6	10	12	13	21
Total	99%	100%	101%	99%	101%	100%	100%	99%
No.	182	182	181	182	182	182	182	182

TABLE 8

Sector Distribution of loadings based on modified surface geostrophic 24 hour back trajectories from London. Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	1	2	2	5	6	8	2	3	4	4
NE	4	4	4	3	4	5	4	5	6	6
E	6	6	6	5	2	4	5	2	5	3
SE	28	20	18	18	17	8	13	11	11	15
S	14	15	15	15	13	19	13	29	16	14
SW	26	28	26	25	32	25	32	27	32	29
W	9	13	15	15	12	15	18	12	14	13
NW	3	3	3	3	3	2	3	3	3	6
UNKNOWN	8	9	12	11	10	14	9	8	8	11
Total	99%	100%	101%	100%	99%	100%	99%	100%	99%	101%
N	127	142	142	138	127	127	128	107	111	163

TABLE 9

Sector Distribution of loadings based on modified surface geostrophic 48 hour back trajectories from London. Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	8	7	8	9	8	8	6	4	5	5
NE	3	5	5	4	5	7	4	17	5	8
E	2	2	2	2	1	1	1	1	1	2
SE	13	10	9	13	16	11	8	6	7	9
S	14	10	7	7	6	9	6	6	6	8
SW	29	28	26	24	18	24	29	20	25	22
W	4	7	9	6	4	6	8	5	6	7
NW	12	15	16	15	13	13	17	21	22	16
UNKNOWN	15	16	18	21	30	21	21	19	22	22
Total	100%	100%	100%	101%	101%	101%	100%	99%	99%	99%
N	127	142	142	138	127	127	128	107	111	163

TABLE 10

Sector Distribution of loadings based on 850 mb 24 hour back trajectories from London.
Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	1	2	2	4	7	9	2	4	5	4
NE	1	1	1	1	1	1	1	1	1	1
E	0	0	0	0	0	0	0	0	0	0
SE	1	1	1	1	2	2	2	1	1	2
S	6	6	7	6	6	5	4	3	6	5
SW	22	24	24	28	29	29	26	28	18	27
W	32	35	35	32	25	26	41	38	42	30
NW	5	6	8	6	7	8	7	7	8	6
UNKNOWN	32	26	22	21	24	21	18	17	20	25
Total	100%	101%	100%	99%	101%	101%	101%	99%	101%	100%
N	127	142	142	138	127	127	128	107	111	163

TABLE 11

Sector Distribution of loadings based on 850 mb 48 hour back trajectories from London.
Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	0	1	2	4	6	6	1	1	2	5
NE	1	1	1	1	1	1	1	1	1	1
E	0	0	0	0	0	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0
S	4	3	3	5	5	7	3	3	3	3
SW	31	33	32	33	34	30	35	31	25	30
W	25	26	29	26	21	22	31	33	35	29
NW	8	8	10	9	8	10	10	13	14	9
UNKNOWN	32	27	23	23	25	24	20	18	20	26
Total	101%	99%	100%	101%	100%	100%	101%	100%	100%	100%
N	127	142	142	138	127	127	128	107	111	163

TABLE 12

Sector Distribution of loadings based on modified surface geostrophic 24 hour back trajectories from Kingston. Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	5	5	7	6	5	7	7	11	9	4
NE	3	3	5	5	6	1	2	5	3	3
E	2	1	1	0	0	1	1	0	0	1
SE	10	8	9	9	9	16	7	7	7	18
S	26	23	21	26	31	17	18	14	15	20
SW	40	42	39	33	32	33	42	39	39	35
W	3	7	7	7	2	11	13	12	15	7
NW	1	2	2	4	3	3	2	5	5	2
UNKNOWN	10	10	9	10	11	12	8	8	7	10
Total	100%	101%	100%	100%	99%	101%	100%	101%	100%	100%
N	129	125	126	125	104	110	114	106	104	148

TABLE 13

Sector Distribution of loadings based on modified surface geostrophic 48 hour back trajectories from Kingston. Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	1	1	2	2	2	1	0	1	1	1
NE	0	0	0	1	2	1	0	1	1	1
E	0	0	0	0	1	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0
S	7	7	7	8	10	9	7	5	6	10
SW	43	40	39	39	43	37	35	33	29	40
W	11	17	18	19	17	21	24	19	32	16
NW	2	2	3	4	3	2	2	4	3	2
UNKNOWN	36	33	30	27	22	28	31	27	27	29
Total	99%	100%	99%	100%	100%	99%	99%	100%	99%	99%
N	129	125	126	125	104	110	114	106	104	148

TABLE 14

Sector Distribution of loadings absed on 850 mb 24 hour back trajectories from Kingston.
Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	6	5	9	9	10	9	8	13	12	7
NE	6	5	6	4	5	6	5	6	5	7
E	1	1	1	1	1	1	1	1	1	1
SE	6	6	5	7	8	7	5	2	3	8
S	21	20	15	18	22	11	14	15	15	18
SW	30	30	26	27	25	26	29	19	22	28
W	6	13	12	11	9	16	19	21	24	9
NW	6	6	7	5	3	4	6	7	6	4
UNKNOWN	17	15	18	17	17	19	13	16	13	17
Total	99%	101%	99%	99%	100%	99%	100%	100%	101%	99%
N	129	125	126	125	104	110	114	106	104	148

TABLE 15

Sector Distribution of loadings based on 850 mb 48 hour back trajectories from Kingston.
Entries are percentages of total loadings.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	1	1	2	2	2	1	1	3	3	1
NE	1	1	1	1	1	0	0	0	1	1
E	0	0	0	0	1	0	0	0	0	0
SE	0	0	0	0	0	0	0	0	0	0
S	7	7	7	8	9	9	7	5	6	11
SW	28	26	27	25	25	24	23	24	29	25
W	21	25	22	20	21	26	30	26	27	25
NW	4	4	7	7	5	5	7	9	8	4
UNKNOWN	37	36	33	36	35	34	32	32	36	34
Total	99%	100%	99%	99%	99%	99%	99%	99%	100%	101%
N	129	125	126	125	104	110	114	106	104	148

TABLE 16

Number of analyzed samples in the various 24 hour geostrophic sectors trajectory sectors. Dorset.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	20	20	20	20	14	14	16	14	14	22
NE	13	12	12	12	10	10	11	10	9	14
E	7	6	6	6	4	4	4	4	4	7
SE	17	17	17	17	15	15	14	15	15	17
S	33	32	32	32	32	32	31	31	32	35
SW	45	46	46	46	41	41	40	39	39	49
W	21	21	21	21	17	17	15	17	16	23
NW	9	8	8	8	5	5	6	5	5	10
UNKNOWN	19	20	21	21	19	19	18	19	19	21
No.	184	182	183	183	157	157	155	154	153	198

TABLE 17

Number of analyzed samples in the various 24 hour geostrophic trajectory sectors. London.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^+	Mg^{++}	Gauge Depth
N	6	10	10	10	9	9	9	7	8	12
NE	8	8	8	7	7	7	7	6	7	11
E	5	5	5	5	4	4	3	3	4	5
SE	17	16	16	17	14	14	13	13	14	18
S	18	18	18	19	18	17	18	16	15	23
SW	35	36	36	36	35	35	35	33	33	38
W	16	19	19	18	17	17	17	12	12	23
NW	7	9	9	9	7	7	8	5	6	12
UNKNOWN	15	21	21	17	16	17	18	12	12	21
No.	127	142	142	138	127	127	128	107	111	163

TABLE 18

Number of analyzed samples in the various 24 hour geostrophic trajectory sectors. Kingston.

	H^+	$SO_4^=$	NO_3^-	Cl^-	Na^+	K^+	NH_4^+	Ca^{++}	Mg^{++}	Gauge Depth
N	8	11	10	10	7	8	7	8	8	11
NE	7	7	8	7	5	5	6	6	6	8
E	2	1	1	1	1	1	2	1	1	2
SE	14	13	14	13	12	14	14	12	12	15
S	21	20	20	20	18	18	19	18	18	23
SW	41	40	40	41	38	38	37	36	35	48
W	10	8	9	8	5	7	9	7	7	14
NW	13	12	11	12	6	6	8	6	5	13
UNKNOWN	13	13	13	13	12	13	12	12	12	14
No.	129	125	126	125	104	110	114	106	104	148

Figure 1

The event sampling site locations.

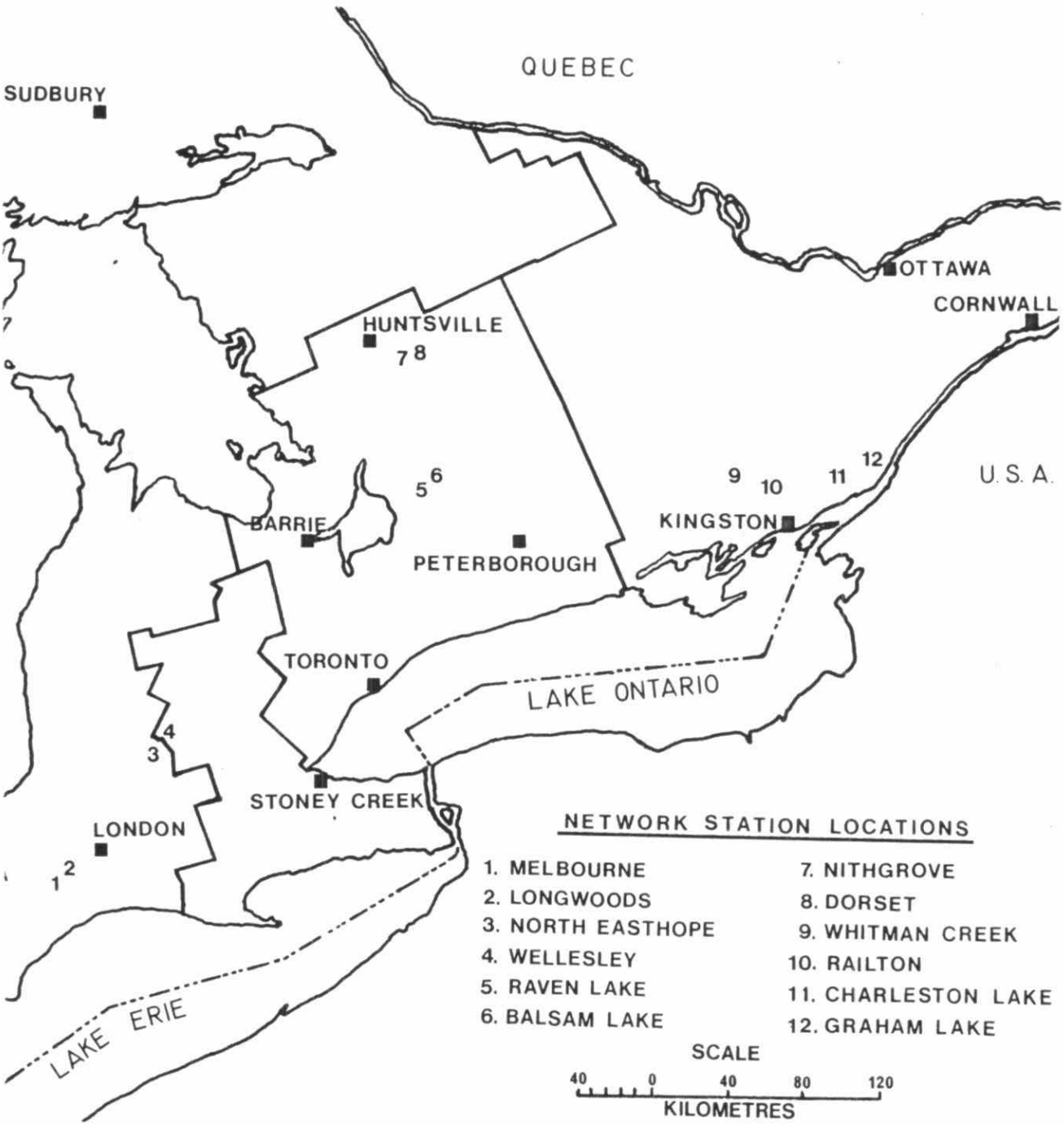
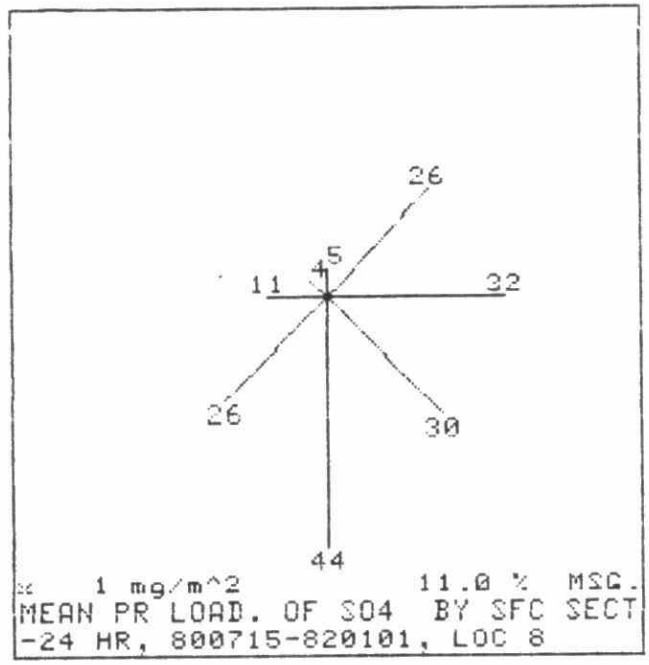
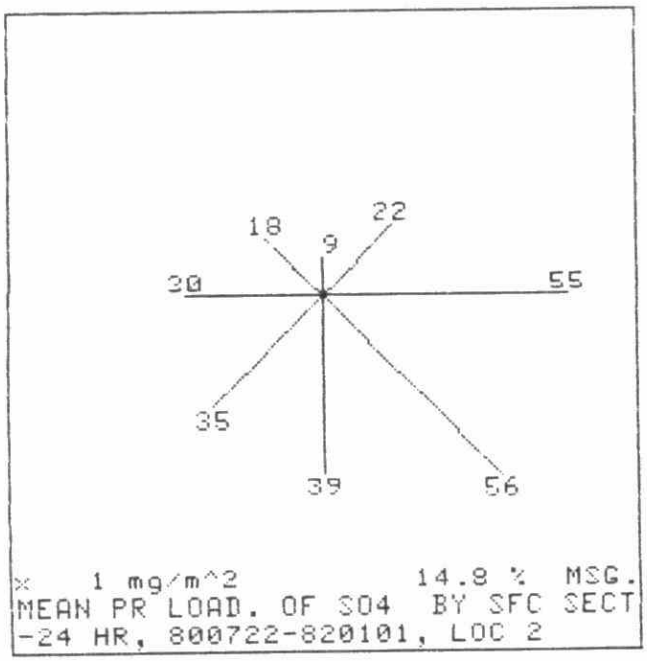


Figure 2


26
5
11
4
32
26
30
44
× 1 mg/m^2 11.0 % MSG.
MEAN PR LOAD. OF SO4 BY SFC SECT
-24 HR, 800715-820101, LOC 8


18
22
9
30
55
35
39
56
× 1 mg/m^2 14.8 % MSG.
MEAN PR LOAD. OF SO4 BY SFC SECT
-24 HR, 800722-820101, LOC 2

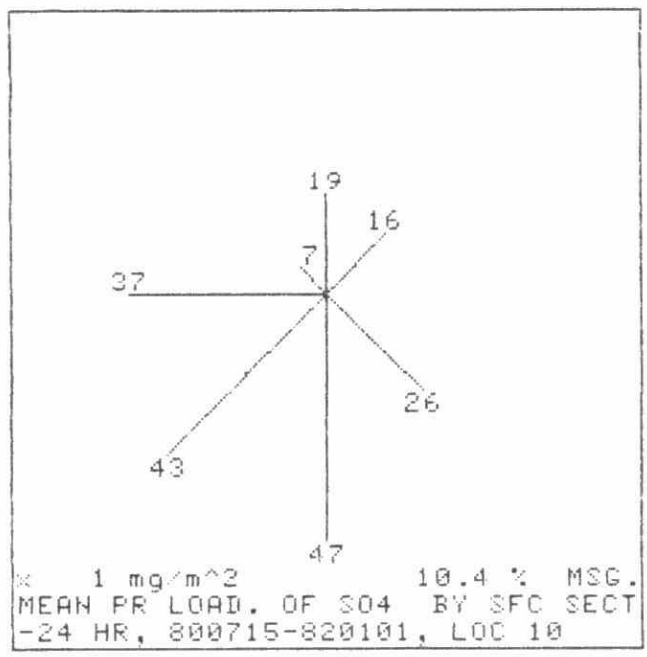
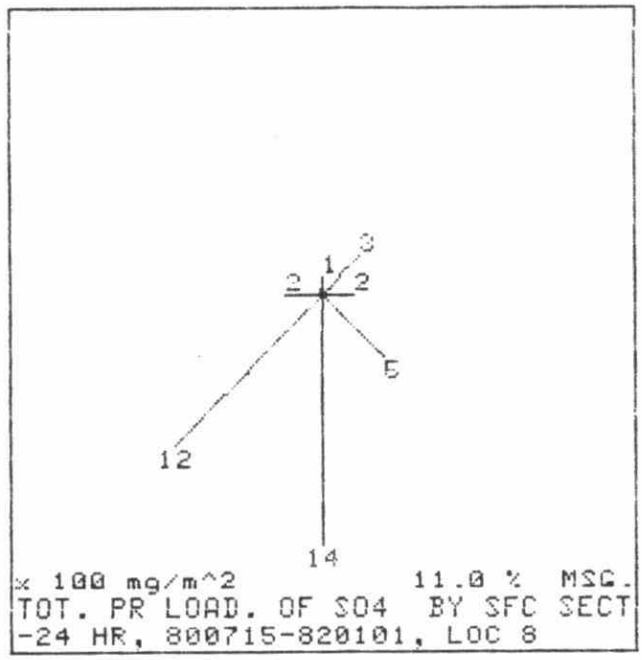
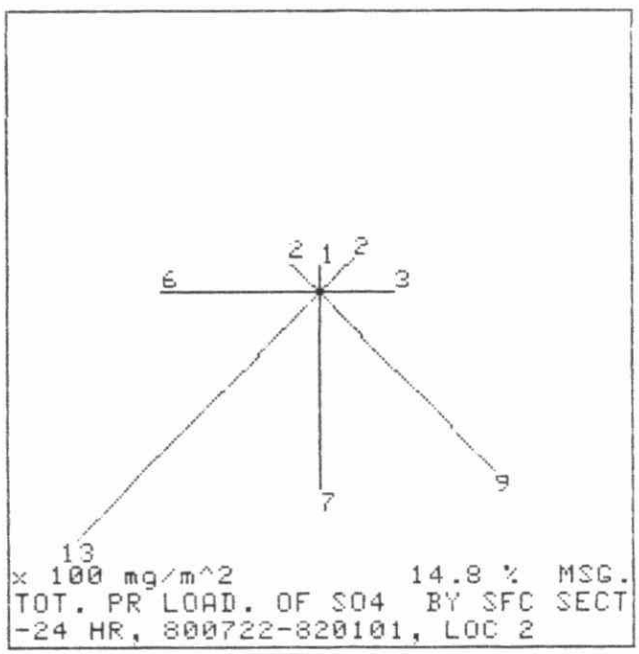

19
16
7
37
26
43
47
× 1 mg/m^2 10.4 % MSG.
MEAN PR LOAD. OF SO4 BY SFC SECT
-24 HR, 800715-820101, LOC 10

Figure 3


3
1
2
2
5
12
14
× 100 mg/m^2
11.0 % MSG.
TOT. PR LOAD. OF SO4 BY SFC SECT
-24 HR, 800715-820101, LOC 8


2
1
2
6
3
7
9
13
× 100 mg/m^2
14.8 % MSG.
TOT. PR LOAD. OF SO4 BY SFC SECT
-24 HR, 800722-820101, LOC 2

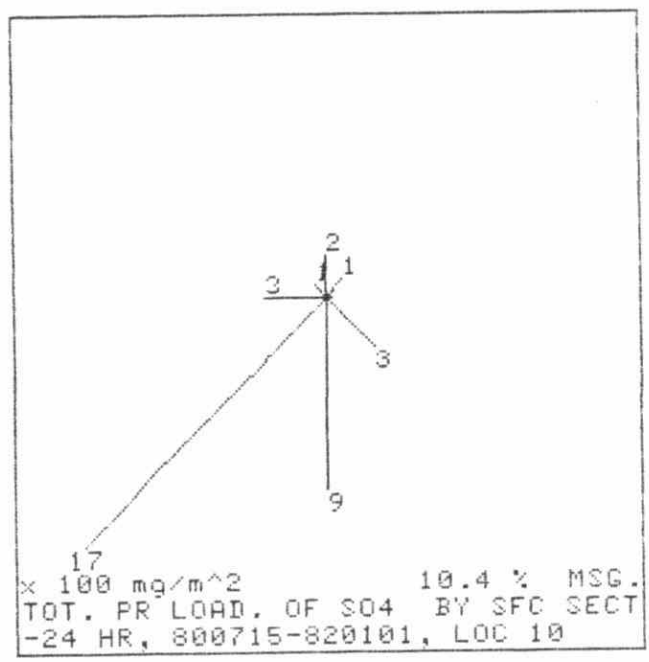
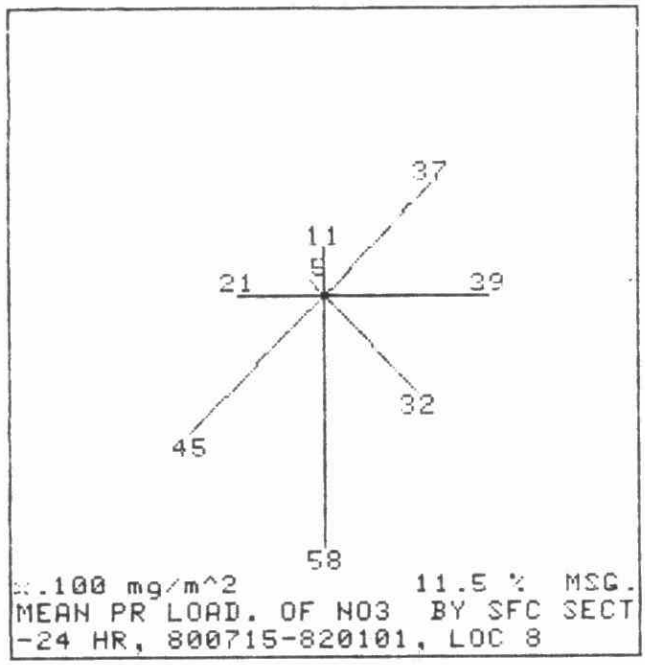
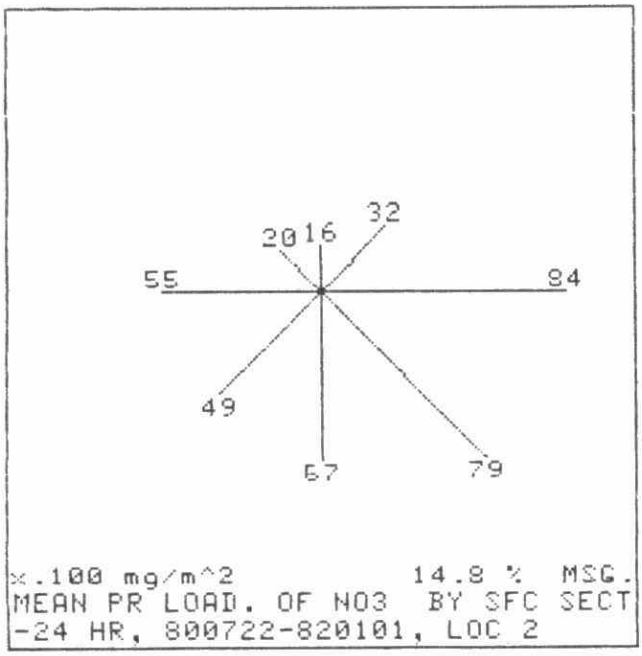

2
1
3
3
9
17
× 100 mg/m^2
10.4 % MSG.
TOT. PR LOAD. OF SO4 BY SFC SECT
-24 HR, 800715-820101, LOC 10

Figure 4


37
11
21
39
32
45
58
×.100 mg/m^2 11.5 % MSG.
MEAN PR LOAD. OF NO3 BY SFC SECT
-24 HR, 800715-820101, LOC 8


32
20
16
55
84
49
57
79
×.100 mg/m^2 14.8 % MSG.
MEAN PR LOAD. OF NO3 BY SFC SECT
-24 HR, 800722-820101, LOC 2

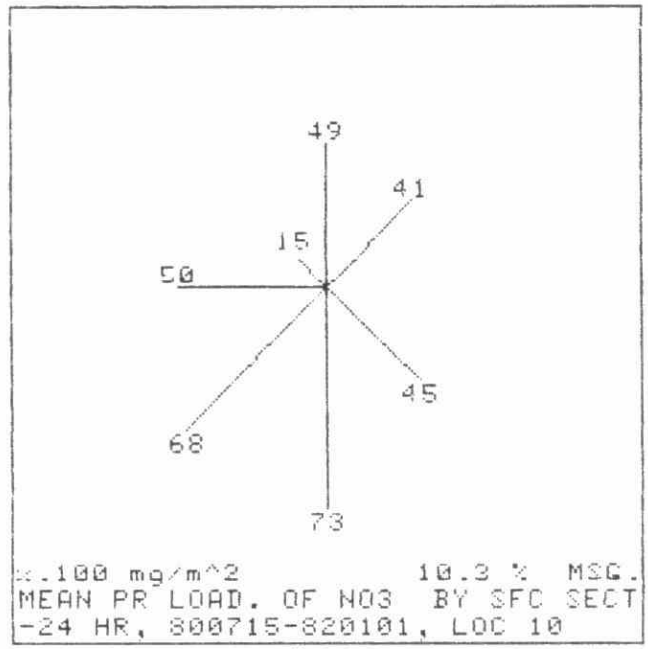
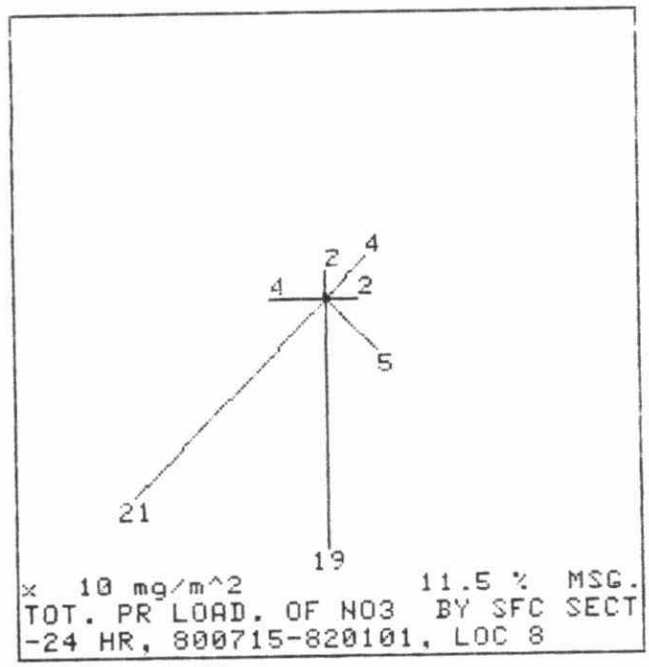
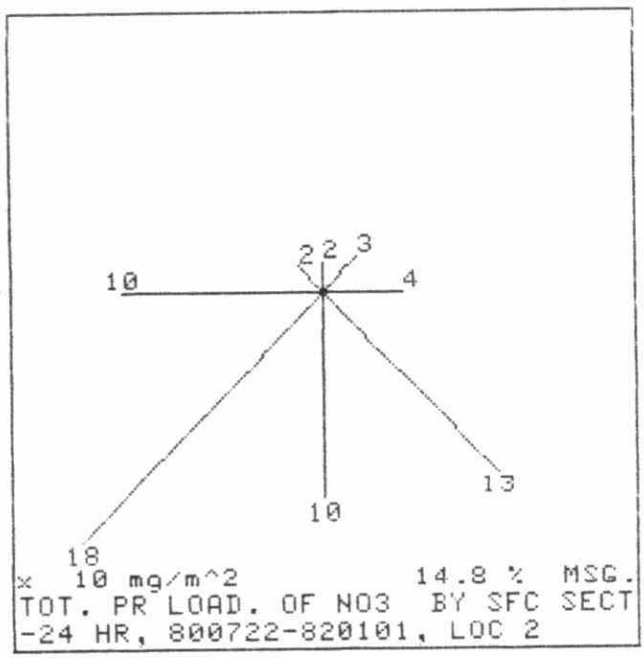

49
41
15
50
45
68
73
×.100 mg/m^2 10.3 % MSG.
MEAN PR LOAD. OF NO3 BY SFC SECT
-24 HR, 800715-820101, LOC 10

Figure 5


4
2
4
2
5
21
19
× 10 mg/m^2
11.5 % MSG.
TOT. PR LOAD. OF NO3 BY SFC SECT
-24 HR, 800715-820101, LOC 8


2 2 3
10
4
13
10
18
× 10 mg/m^2
14.8 % MSG.
TOT. PR LOAD. OF NO3 BY SFC SECT
-24 HR, 800722-820101, LOC 2

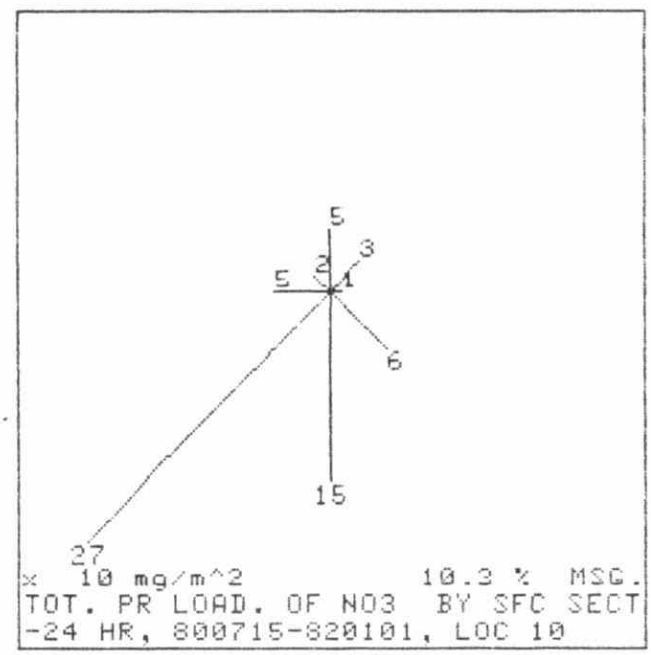
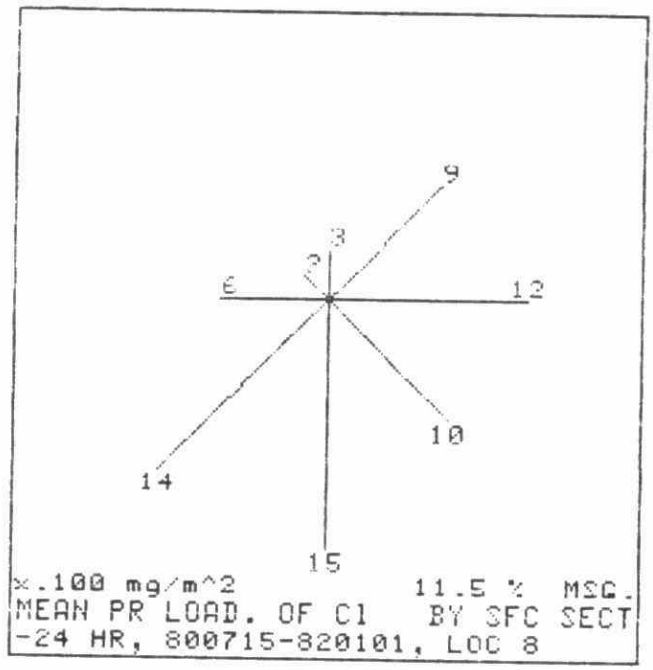
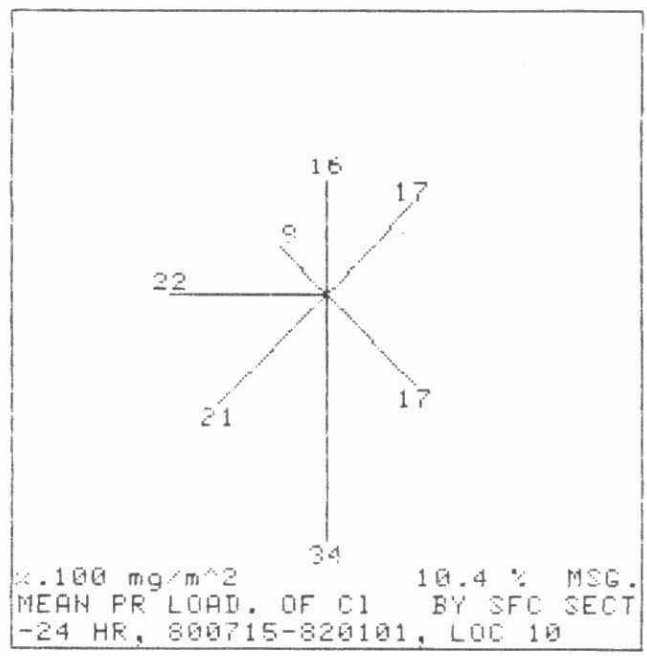

5
3
5
2
1
6
15
27
× 10 mg/m^2
10.3 % MSG.
TOT. PR LOAD. OF NO3 BY SFC SECT
-24 HR, 800715-820101, LOC 10

Figure 6


9
3
2
6
12
10
14
15
x.100 mg/m^2
11.5 % MSG.
MEAN PR LOAD. OF Cl BY SFC SECT
-24 HR, 800715-820101, LOC 8


16
17
9
22
21
17
34
x.100 mg/m^2
10.4 % MSG.
MEAN PR LOAD. OF Cl BY SFC SECT
-24 HR, 800715-820101, LOC 10

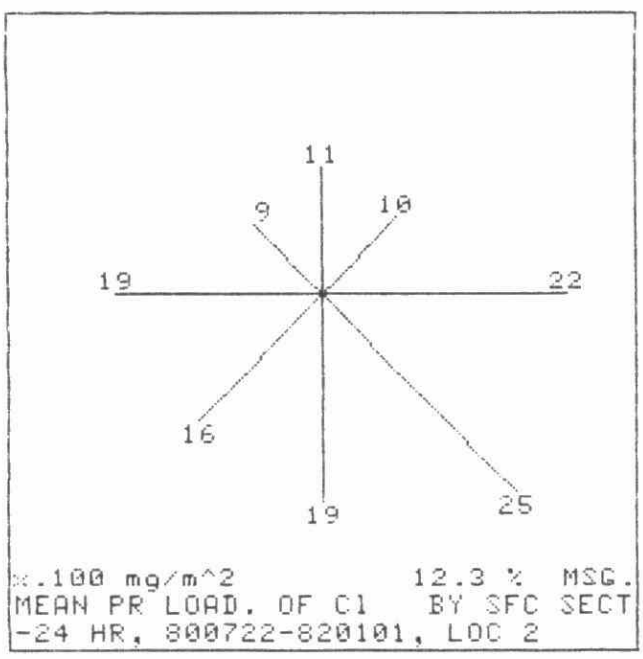
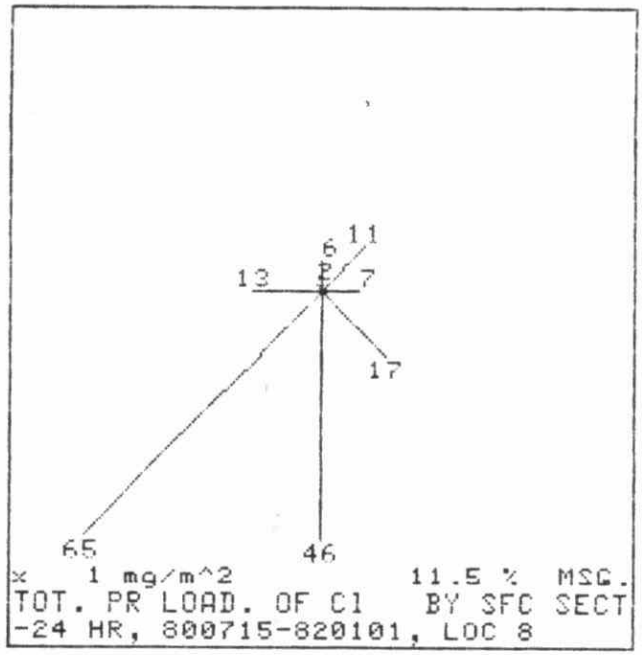
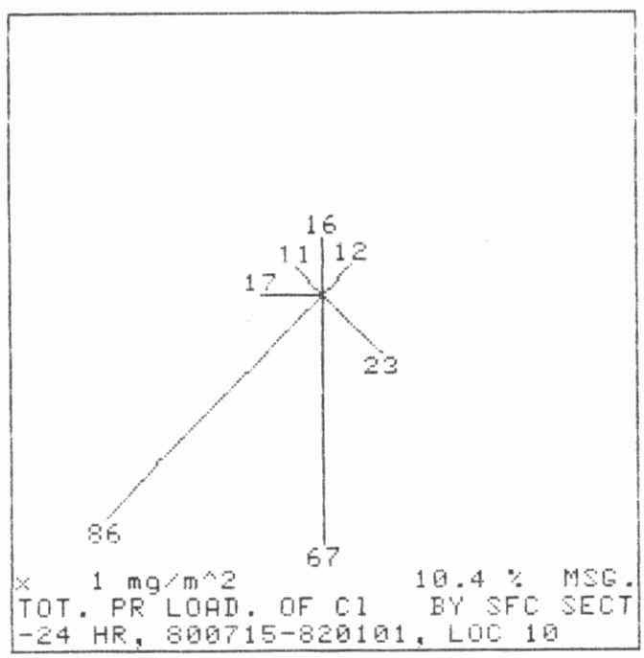

11
9
10
19
22
16
19
25
x.100 mg/m^2
12.3 % MSG.
MEAN PR LOAD. OF Cl BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 7


6
11
13
7
17
65
46
× 1 mg/m^2 11.5 % MSG.
TOT. PR LOAD. OF Cl BY SFC SECT
-24 HR, 800715-820101, LOC 8


16
11
12
17
23
86
67
× 1 mg/m^2 10.4 % MSG.
TOT. PR LOAD. OF Cl BY SFC SECT
-24 HR, 800715-820101, LOC 10

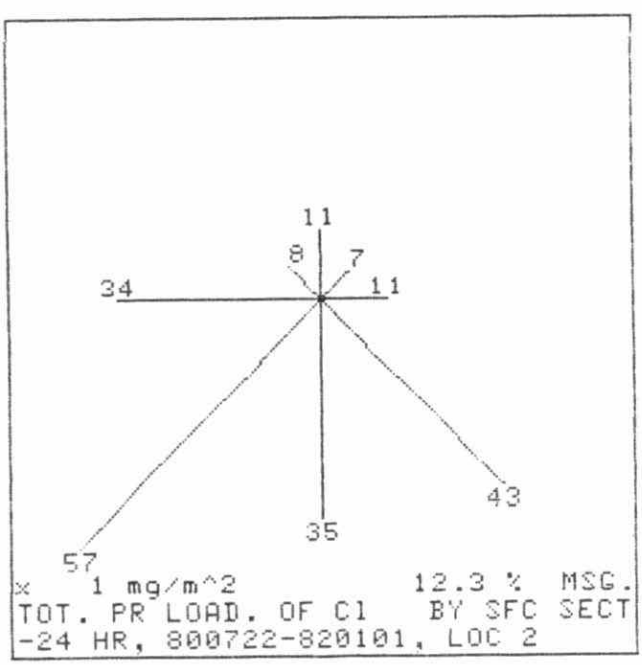
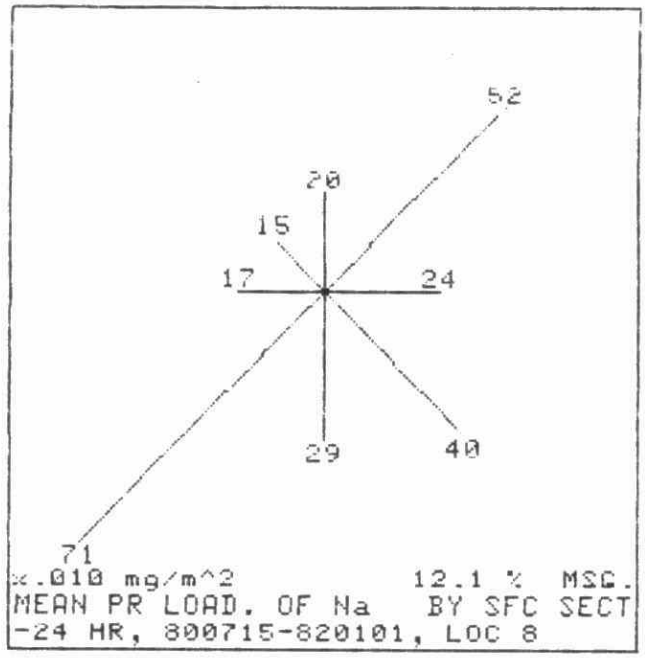
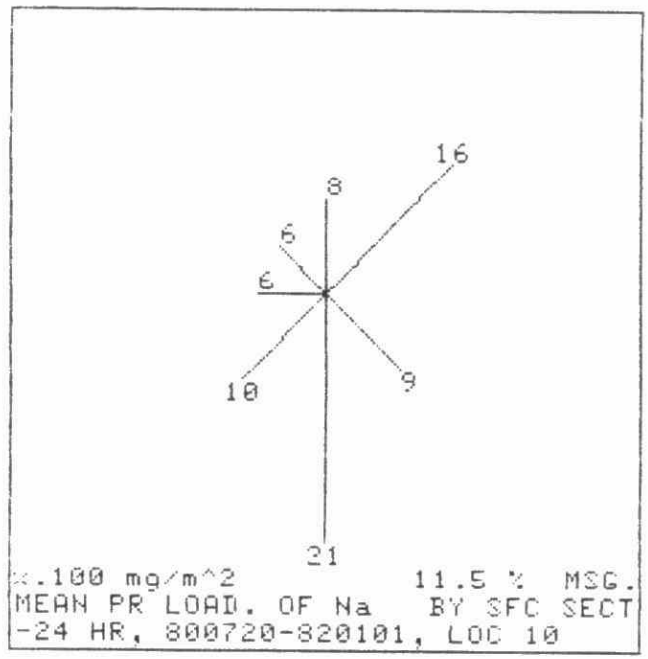

11
8
7
34
11
43
35
57
× 1 mg/m^2 12.3 % MSG.
TOT. PR LOAD. OF Cl BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 8


52
20
15
17
24
29
40
71
×.010 mg/m^2 12.1 % MSG.
MEAN PR LOAD. OF Na BY SFC SECT
-24 HR, 800715-820101, LOC 8


16
8
6
6
10
9
21
×.100 mg/m^2 11.5 % MSG.
MEAN PR LOAD. OF Na BY SFC SECT
-24 HR, 800720-820101, LOC 10

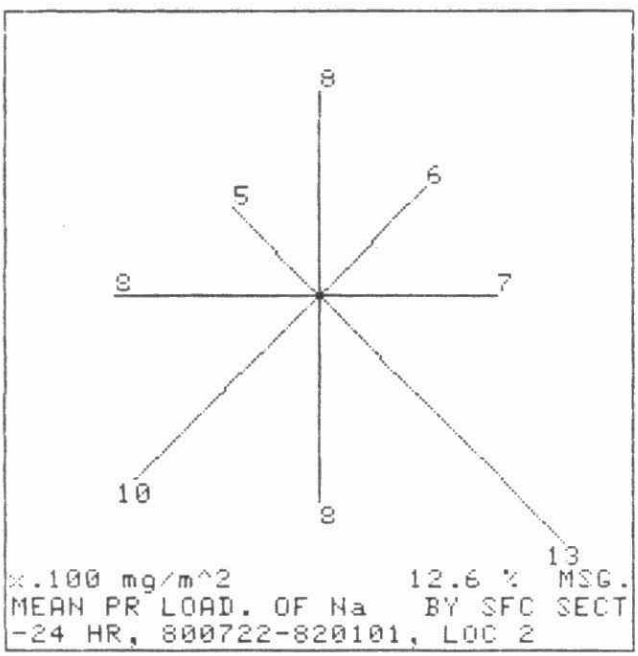
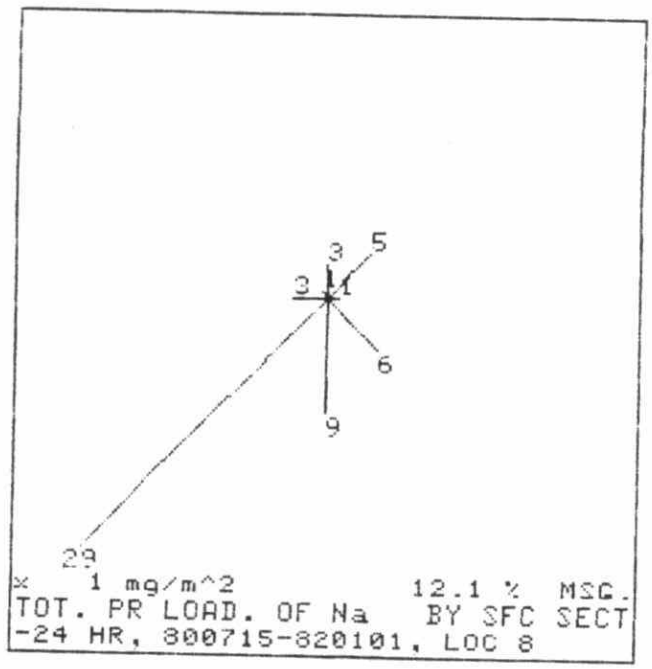
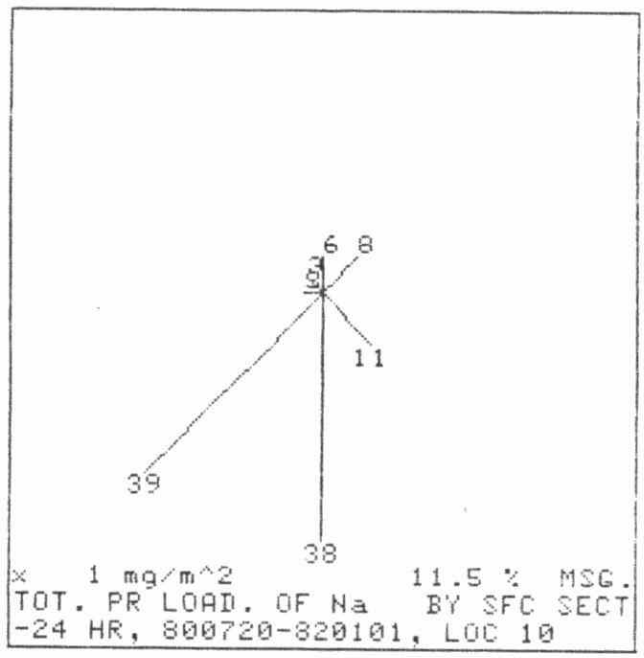

8
5
6
8
7
10
8
13
×.100 mg/m^2 12.6 % MSG.
MEAN PR LOAD. OF Na BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 9


3
5
3
1
6
9
29
× 1 mg/m^2 12.1 % MSG.
TOT. PR LOAD. OF Na BY SFC SECT
-24 HR, 800715-820101, LOC 8


6
8
11
39
38
× 1 mg/m^2 11.5 % MSG.
TOT. PR LOAD. OF Na BY SFC SECT
-24 HR, 800720-820101, LOC 10

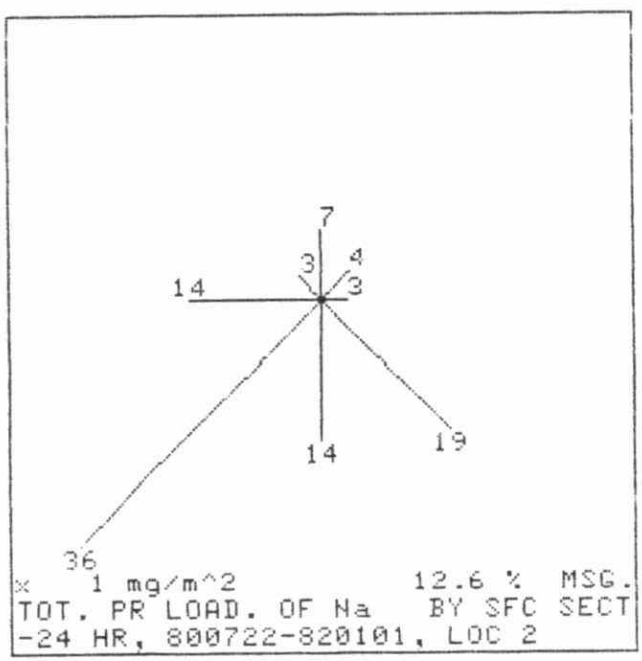
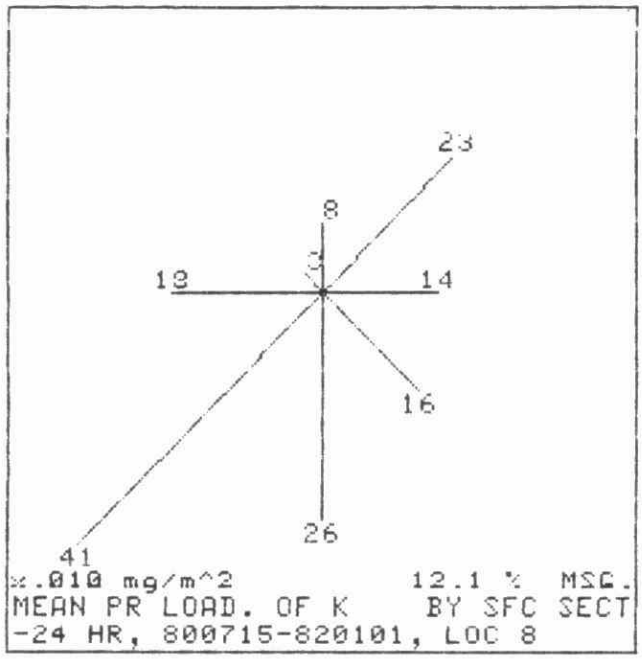
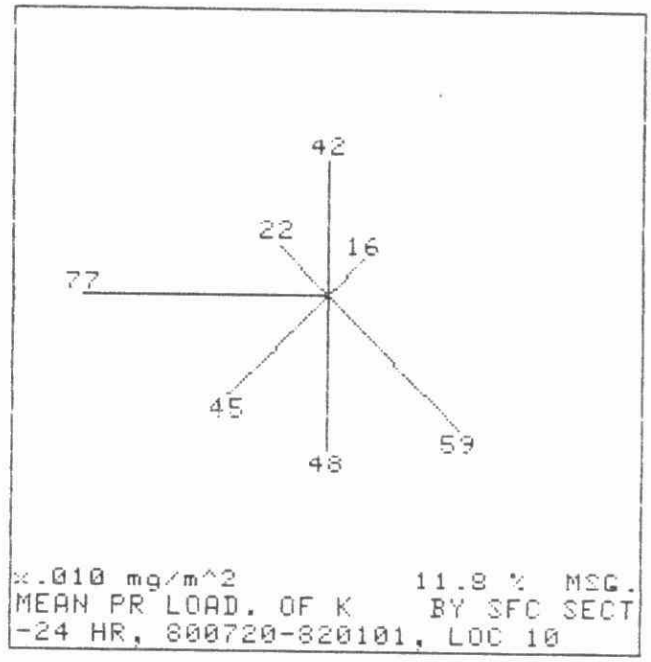

7
3
4
14
3
14
19
36
× 1 mg/m^2 12.6 % MSG.
TOT. PR LOAD. OF Na BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 10


23
8
13
14
16
26
41
×.010 mg/m^2 12.1 % MSG.
MEAN PR LOAD. OF K BY SFC SECT
-24 HR, 800715-820101, LOC 8


42
22
16
77
45
59
48
×.010 mg/m^2 11.8 % MSG.
MEAN PR LOAD. OF K BY SFC SECT
-24 HR, 800720-820101, LOC 10

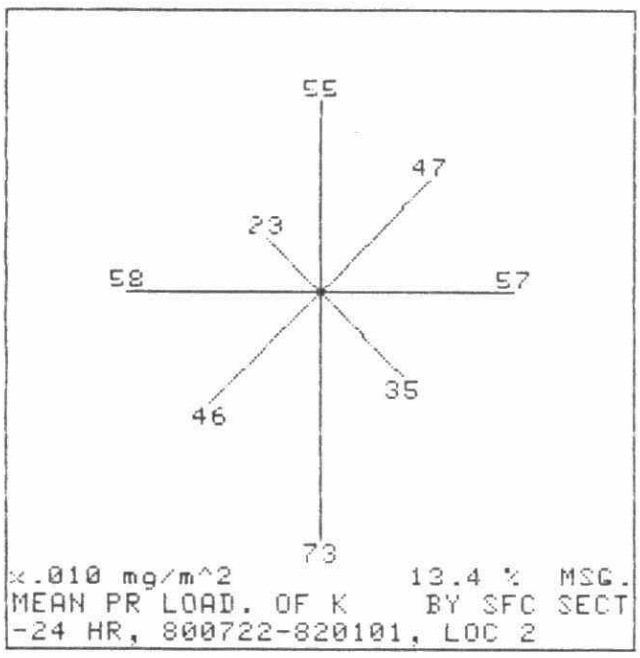
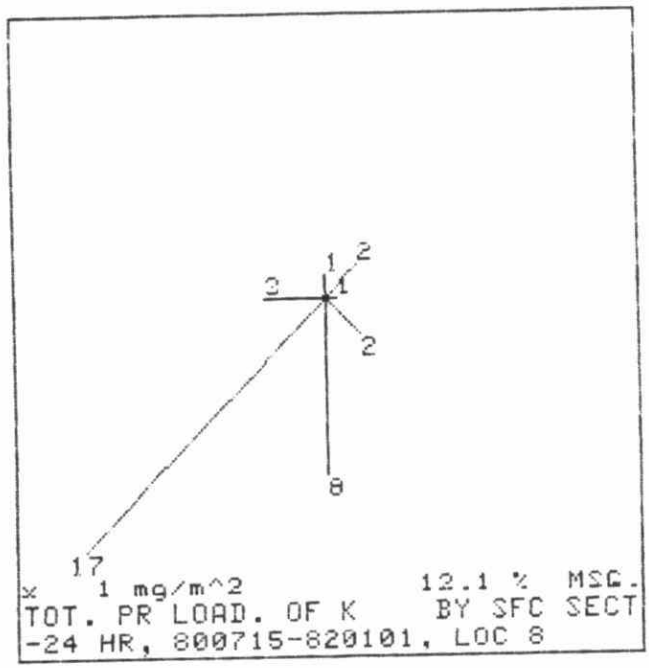
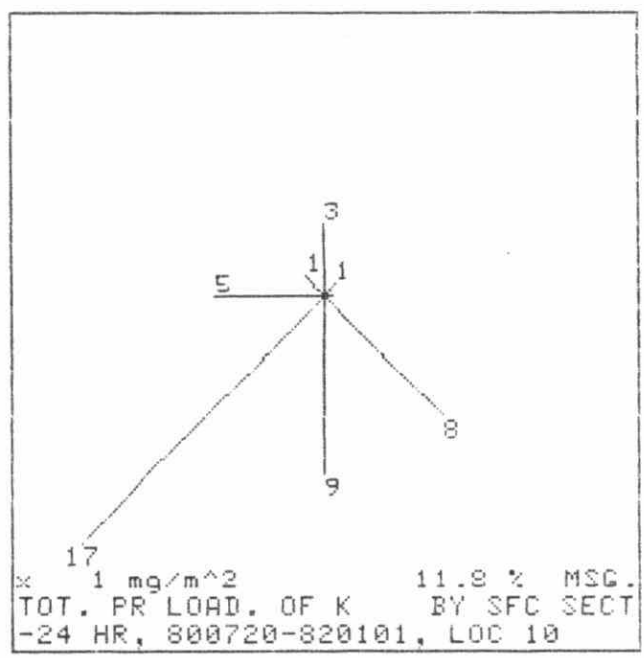

55
47
23
58
57
35
46
73
×.010 mg/m^2 13.4 % MSG.
MEAN PR LOAD. OF K BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 11


1 2
3 1
2
8
17
× 1 mg/m^2 12.1 % MSG.
TOT. PR LOAD. OF K BY SFC SECT
-24 HR, 800715-820101, LOC 8


3
1 1
5
8
9
17
× 1 mg/m^2 11.8 % MSG.
TOT. PR LOAD. OF K BY SFC SECT
-24 HR, 800720-820101, LOC 10

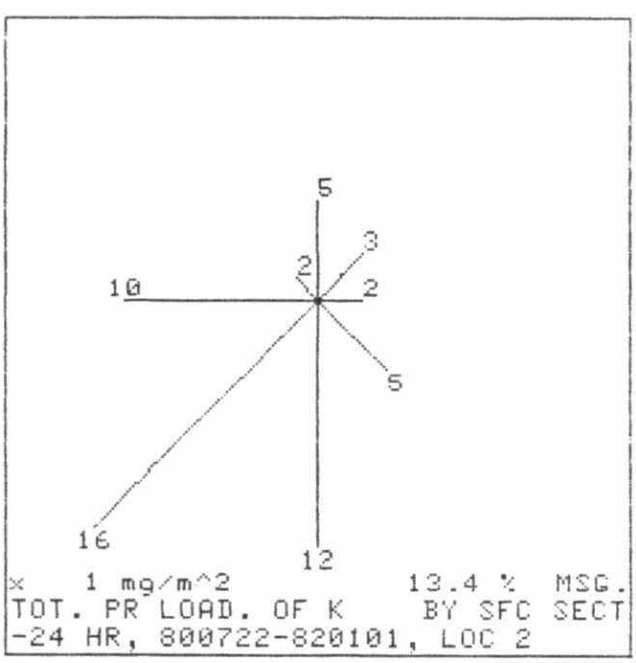
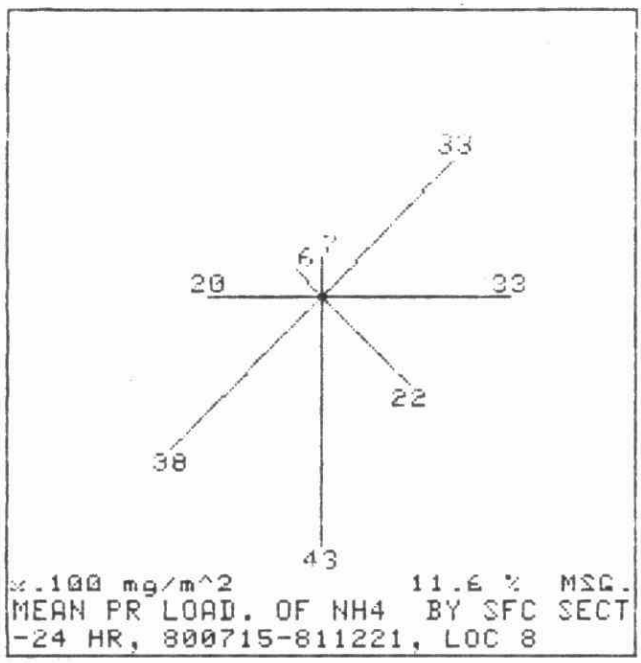
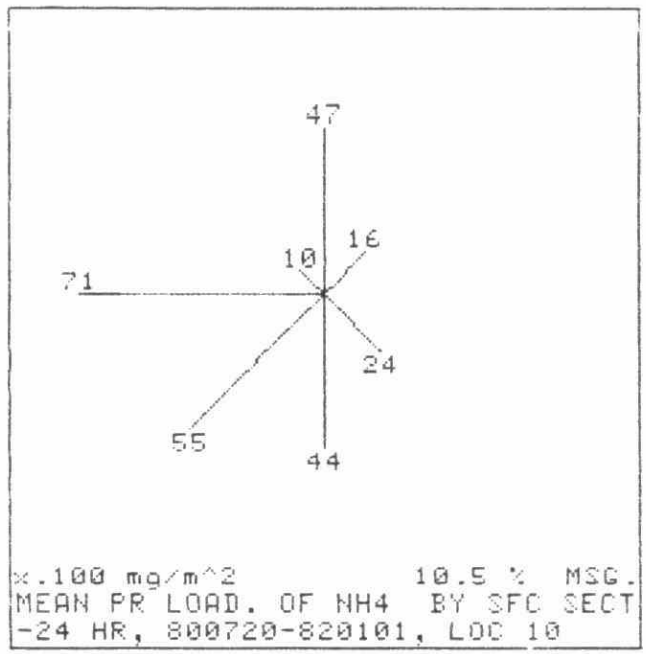

5
3
2
10
2
5
16
12
× 1 mg/m^2 13.4 % MSG.
TOT. PR LOAD. OF K BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 12


33
20
33
22
38
43
x.100 mg/m^2
11.6 % MSG.
MEAN PR LOAD. OF NH4 BY SFC SECT
-24 HR, 800715-811221, LOC 8


47
10
16
71
24
55
44
x.100 mg/m^2
10.5 % MSG.
MEAN PR LOAD. OF NH4 BY SFC SECT
-24 HR, 800720-820101, LOC 10

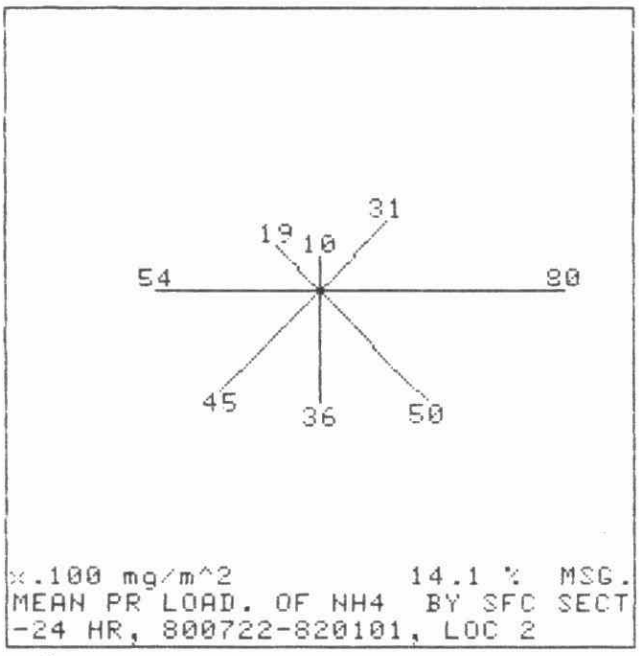
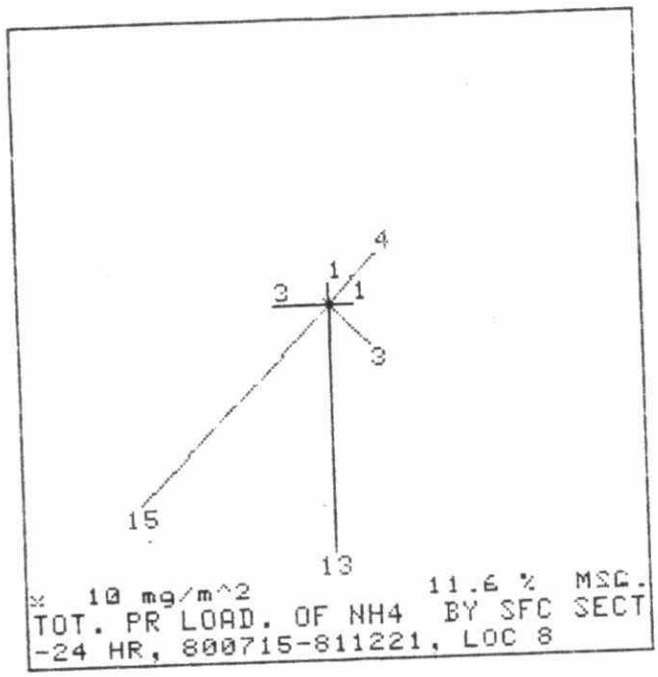
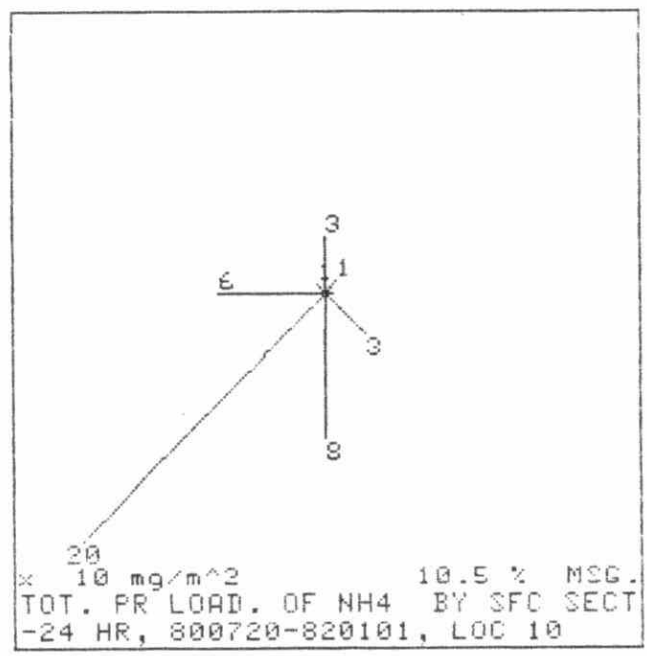

31
19
10
54
80
45
36
50
x.100 mg/m^2
14.1 % MSG.
MEAN PR LOAD. OF NH4 BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 13


4
1
3
1
3
15
13
x 10 mg/m^2
11.6 % MSG.
TOT. PR LOAD. OF NH4 BY SFC SECT
-24 HR, 800715-811221, LOC 8


3
1
6
1
3
8
20
x 10 mg/m^2
10.5 % MSG.
TOT. PR LOAD. OF NH4 BY SFC SECT
-24 HR, 800720-820101, LOC 10

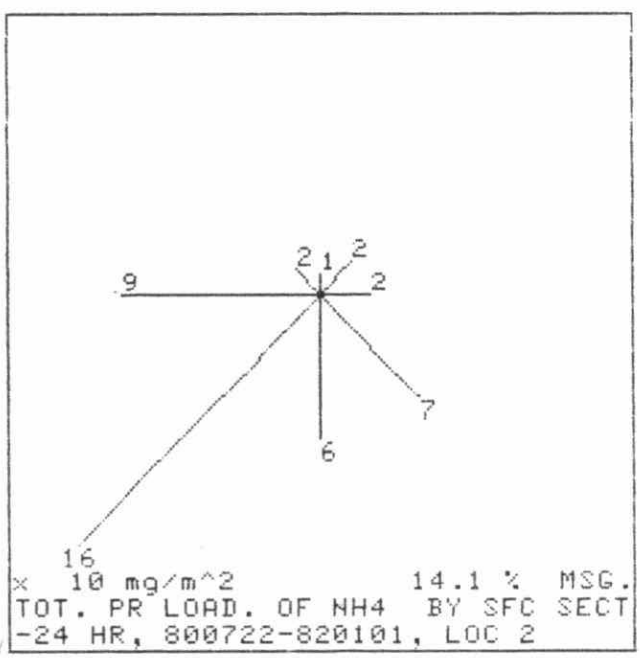
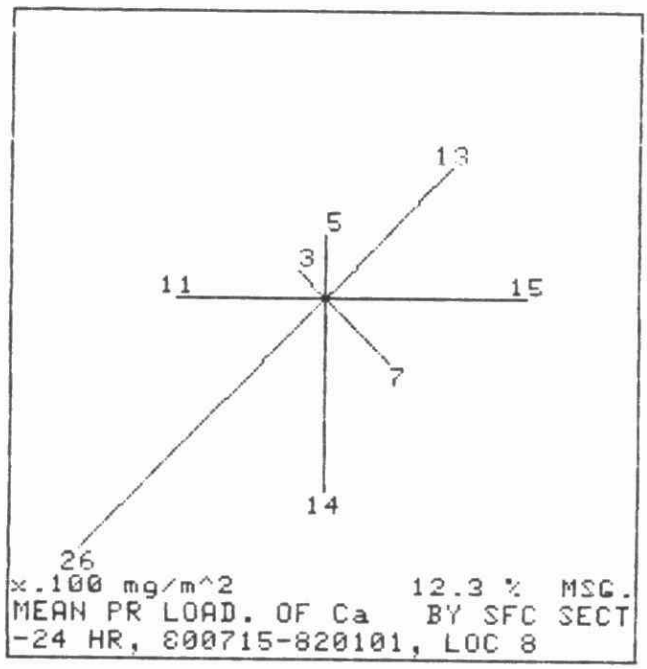
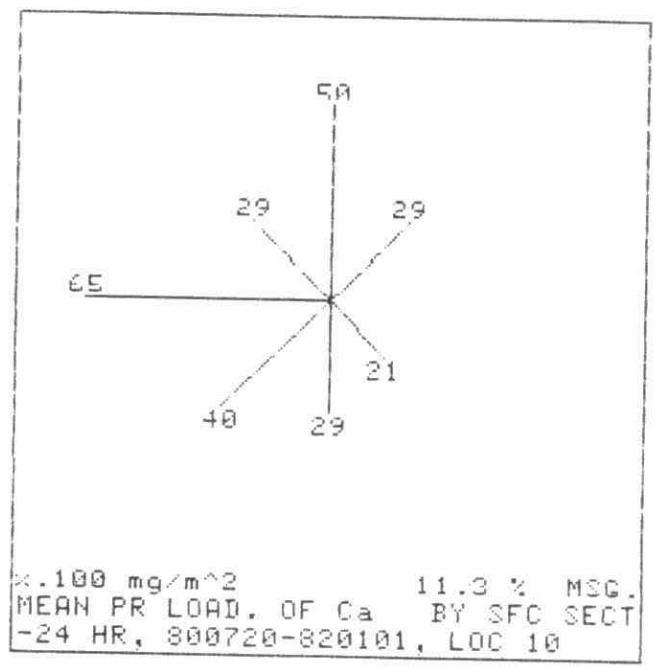

2
1
2
9
2
7
6
16
x 10 mg/m^2
14.1 % MSG.
TOT. PR LOAD. OF NH4 BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 14


13
5
3
11
15
7
14
26
x.100 mg/m^2 12.3 % MSG.
MEAN PR LOAD. OF Ca BY SFC SECT
-24 HR, 800715-820101, LOC 8


50
29
29
65
21
40
29
x.100 mg/m^2 11.3 % MSG.
MEAN PR LOAD. OF Ca BY SFC SECT
-24 HR, 800720-820101, LOC 10

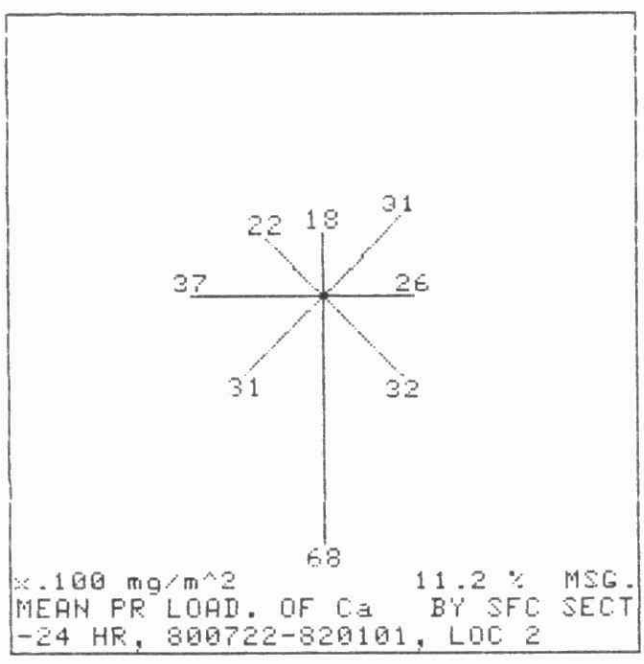
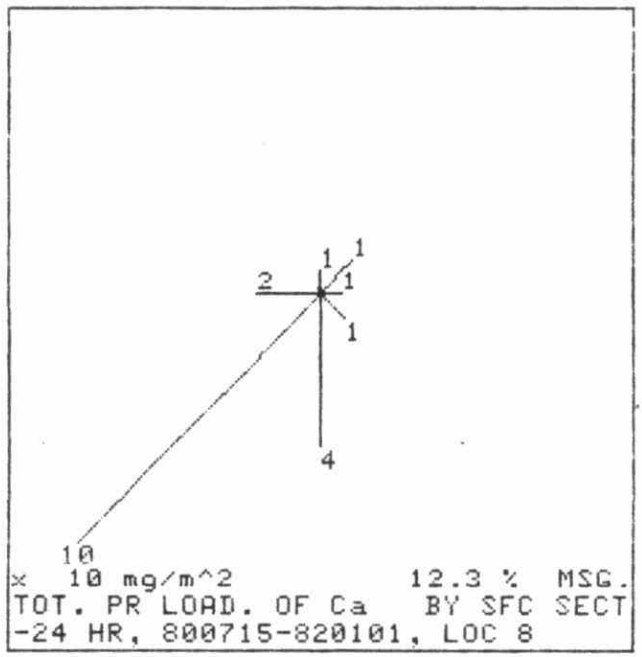
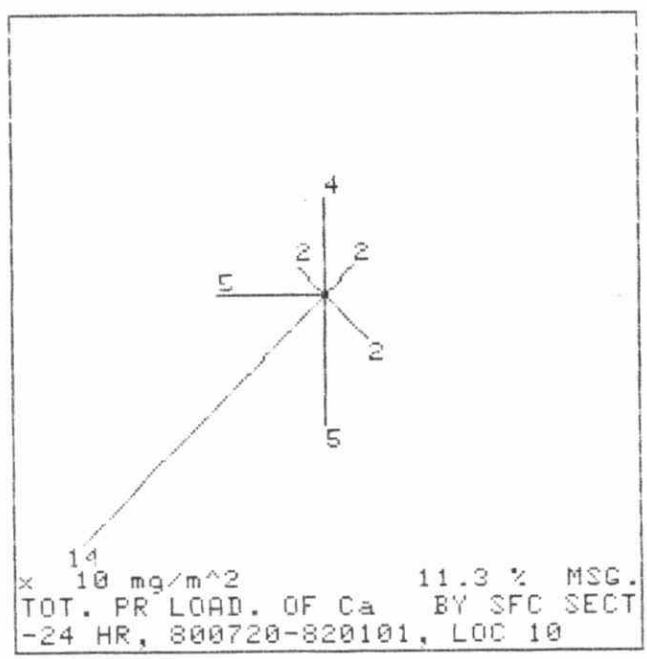

31
22
18
37
26
31
32
68
x.100 mg/m^2 11.2 % MSG.
MEAN PR LOAD. OF Ca BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 15


1
1
2
1
1
4
10
× 10 mg/m^2 12.3 % MSG.
TOT. PR LOAD. OF Ca BY SFC SECT
-24 HR, 800715-820101, LOC 8


4
2
2
5
2
5
14
× 10 mg/m^2 11.3 % MSG.
TOT. PR LOAD. OF Ca BY SFC SECT
-24 HR, 800720-820101, LOC 10

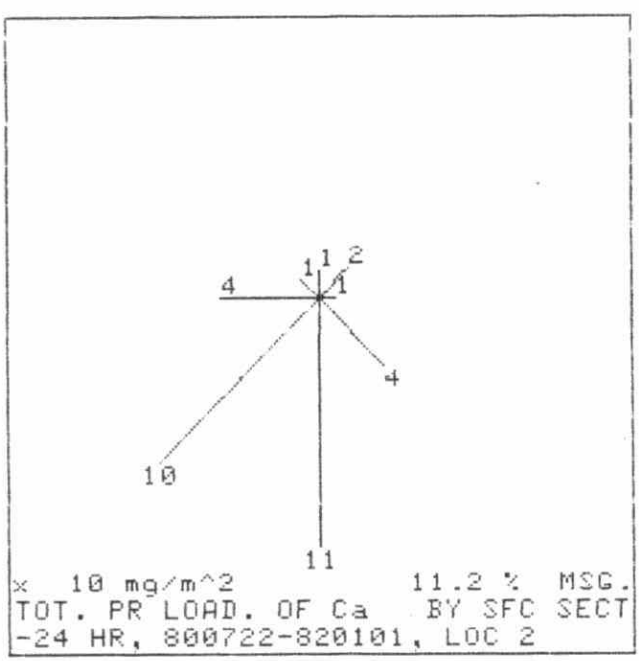
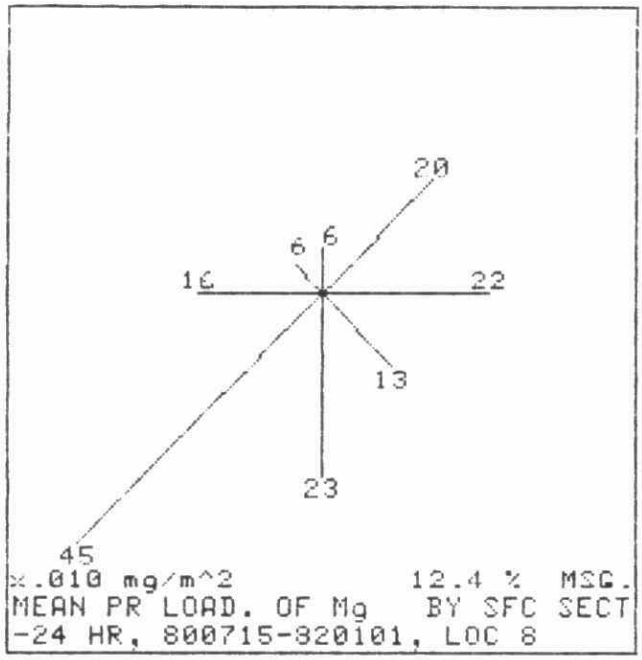
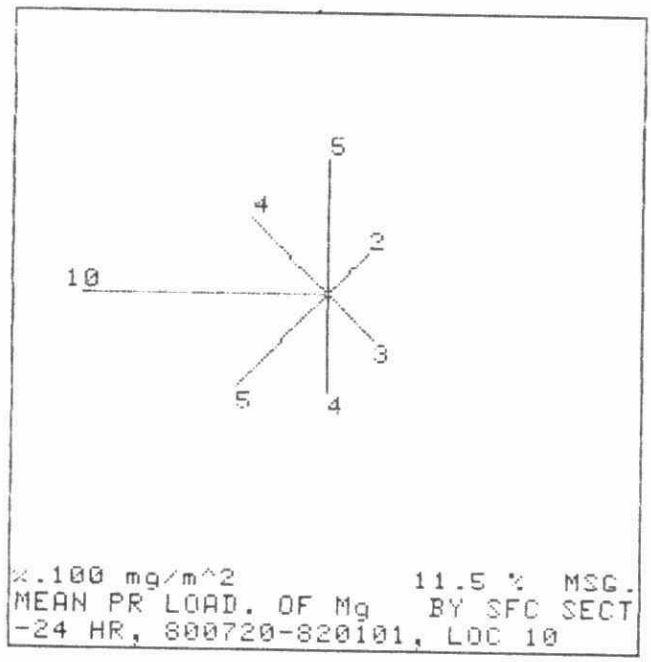

1
1
2
4
1
4
10
11
× 10 mg/m^2 11.2 % MSG.
TOT. PR LOAD. OF Ca BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 16


20
6
6
16
22
13
23
45
×.010 mg/m^2 12.4 % MSG.
MEAN PR LOAD. OF Mg BY SFC SECT
-24 HR, 800715-820101, LOC 8


5
4
2
10
3
5
4
×.100 mg/m^2 11.5 % MSG.
MEAN PR LOAD. OF Mg BY SFC SECT
-24 HR, 800720-820101, LOC 10

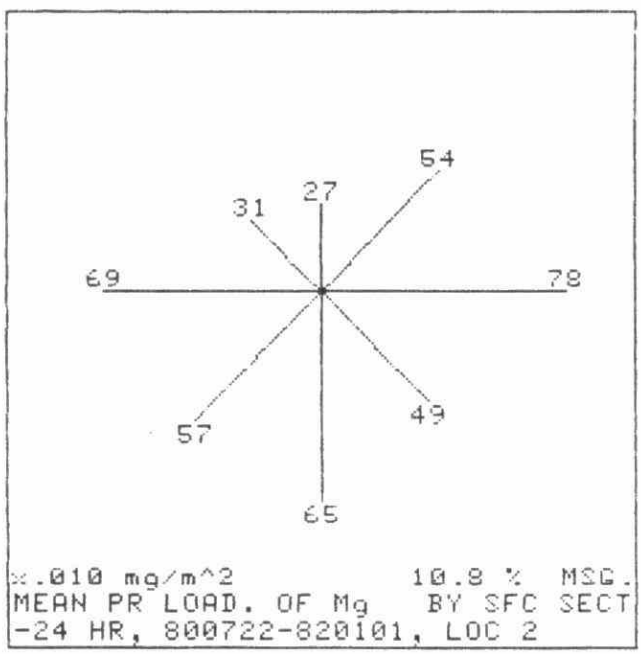
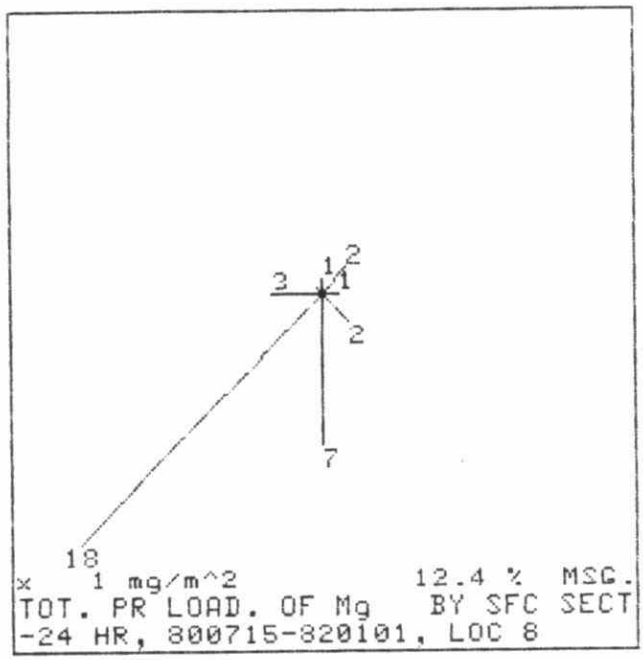
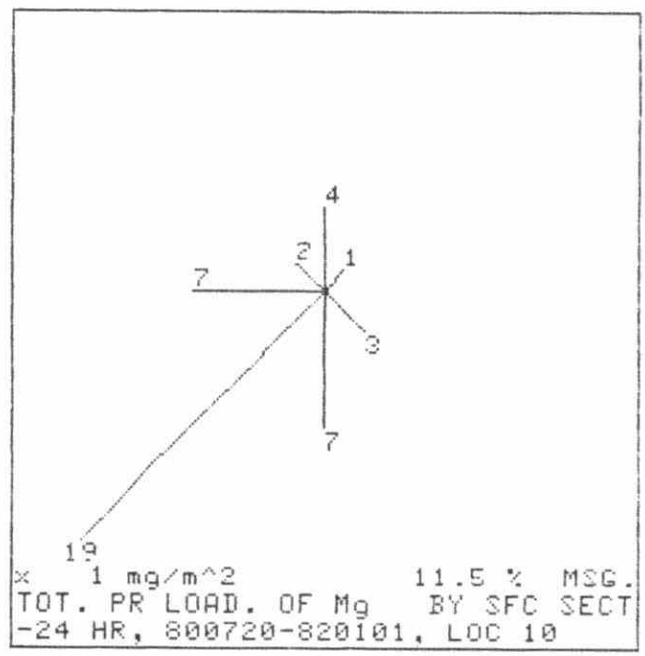

54
27
31
69
78
49
57
65
×.010 mg/m^2 10.8 % MSG.
MEAN PR LOAD. OF Mg BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 17


3
1
1
2
2
7
18
× 1 mg/m^2 12.4 % MSG.
TOT. PR LOAD. OF Mg BY SFC SECT
-24 HR, 800715-820101, LOC 8


4
2
1
7
3
7
19
× 1 mg/m^2 11.5 % MSG.
TOT. PR LOAD. OF Mg BY SFC SECT
-24 HR, 800720-820101, LOC 10

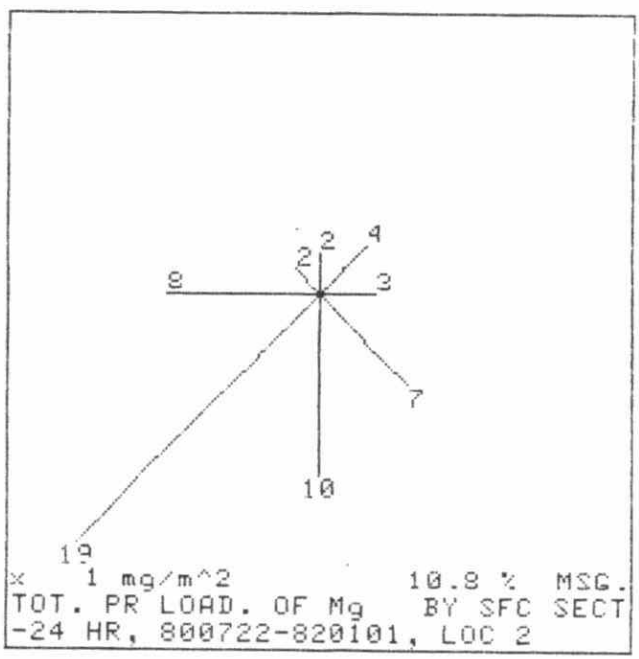
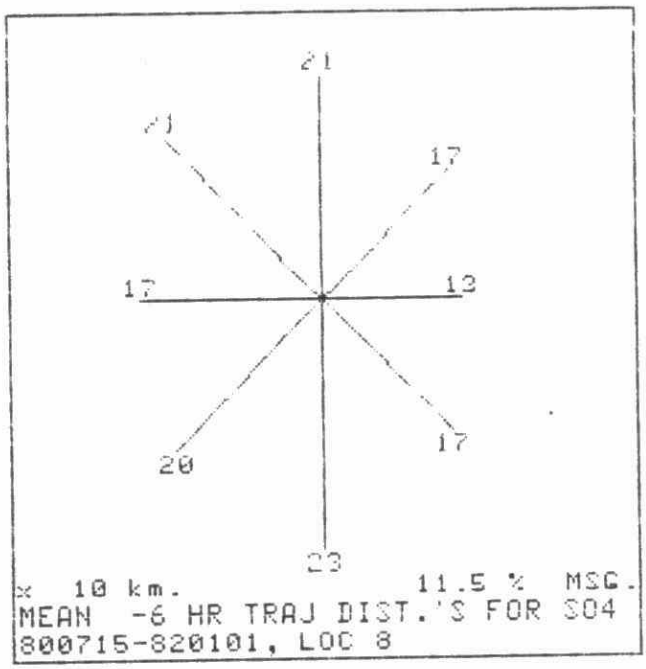
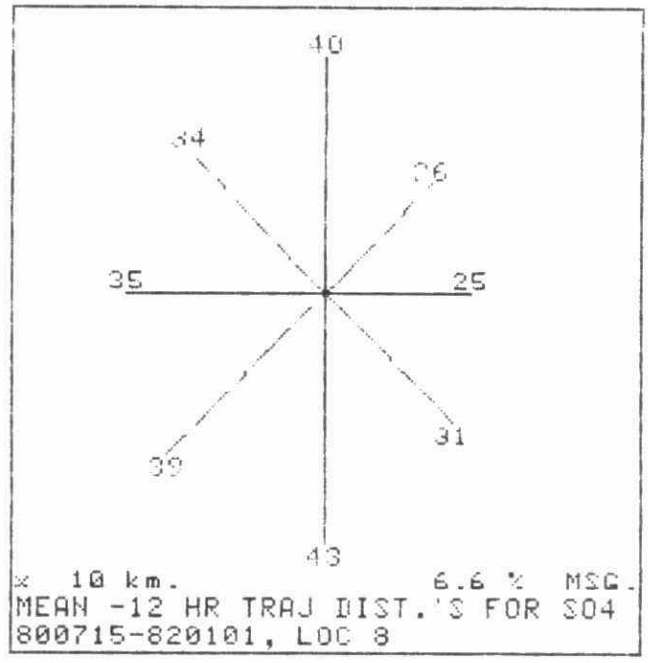
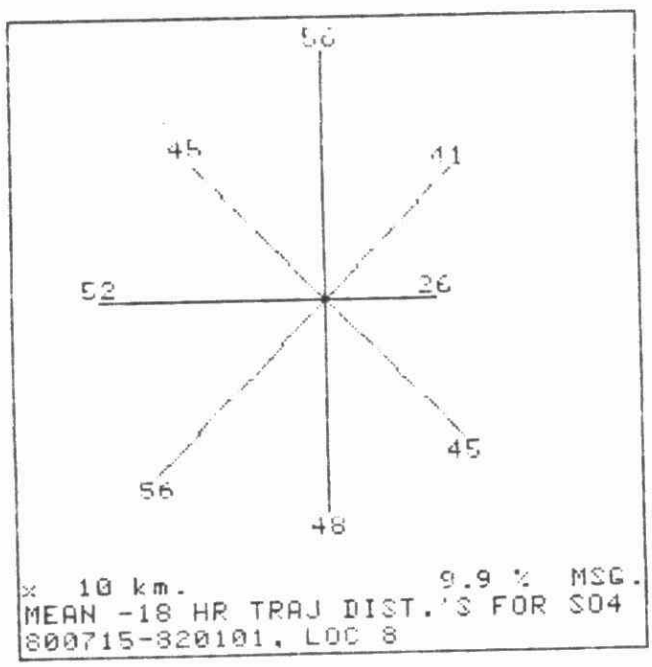

2
2
4
8
3
7
10
19
× 1 mg/m^2 10.8 % MSG.
TOT. PR LOAD. OF Mg BY SFC SECT
-24 HR, 800722-820101, LOC 2

Figure 18A


21
17
17
13
17
20
23
x 10 km.
11.5 % MSG.
MEAN -6 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8


40
34
26
35
25
31
39
43
x 10 km.
6.6 % MSG.
MEAN -12 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8


56
45
41
52
36
45
56
48
x 10 km.
9.9 % MSG.
MEAN -18 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8

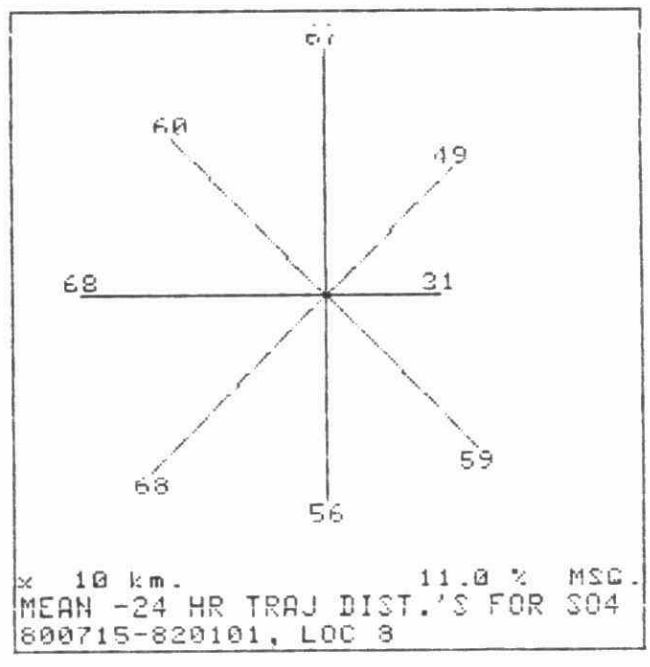
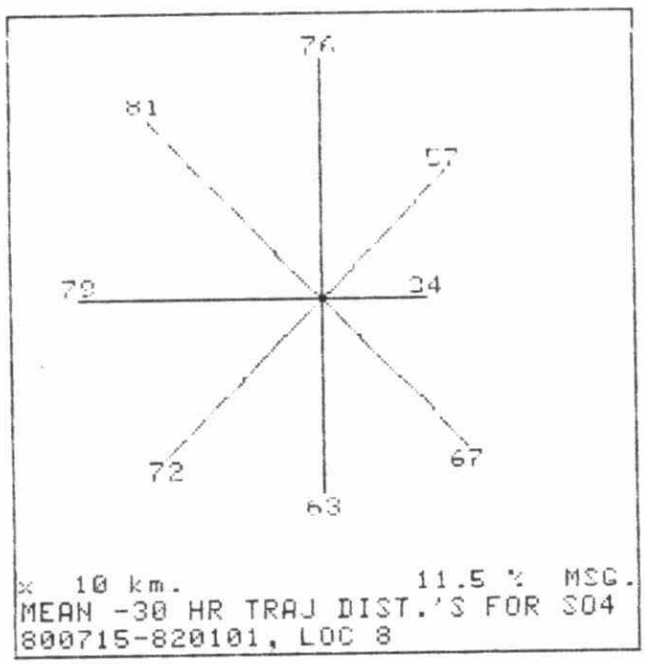
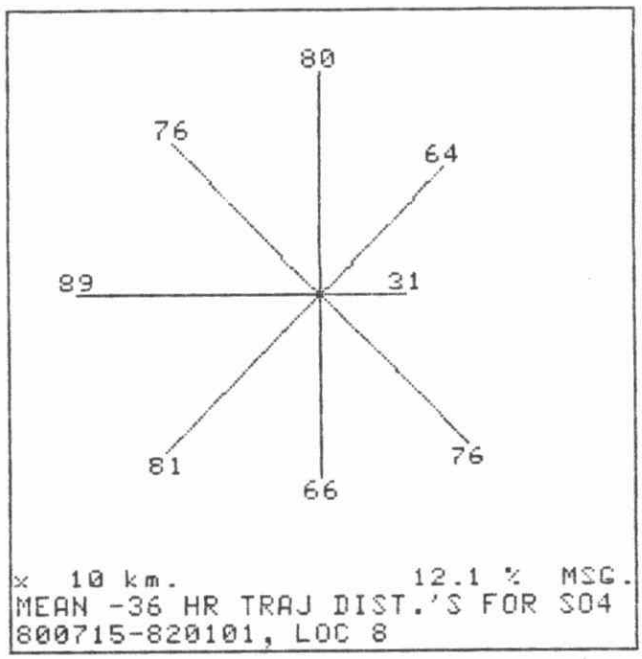
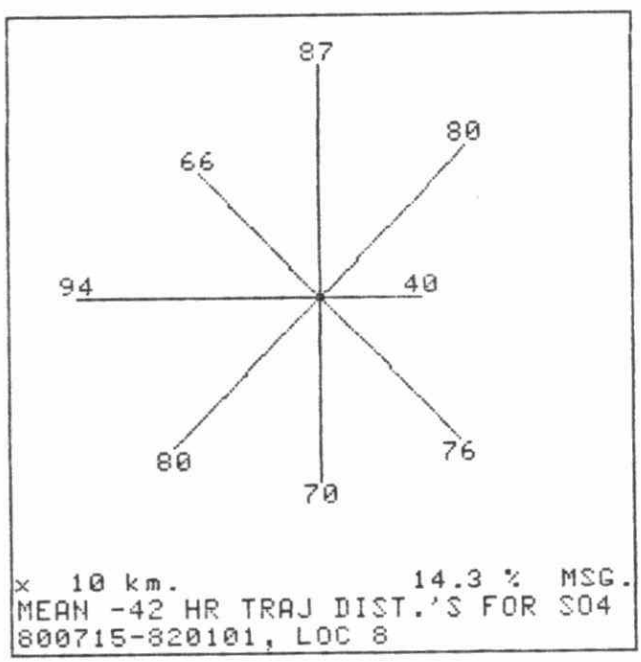

60
49
68
31
68
59
56
x 10 km.
11.0 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8

Figure 18B


76
81
57
79
34
72
67
63
× 10 km.
11.5 % MSG.
MEAN -30 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8


80
76
64
89
31
81
66
76
× 10 km.
12.1 % MSG.
MEAN -36 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8


87
80
66
94
40
80
76
70
× 10 km.
14.3 % MSG.
MEAN -42 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8

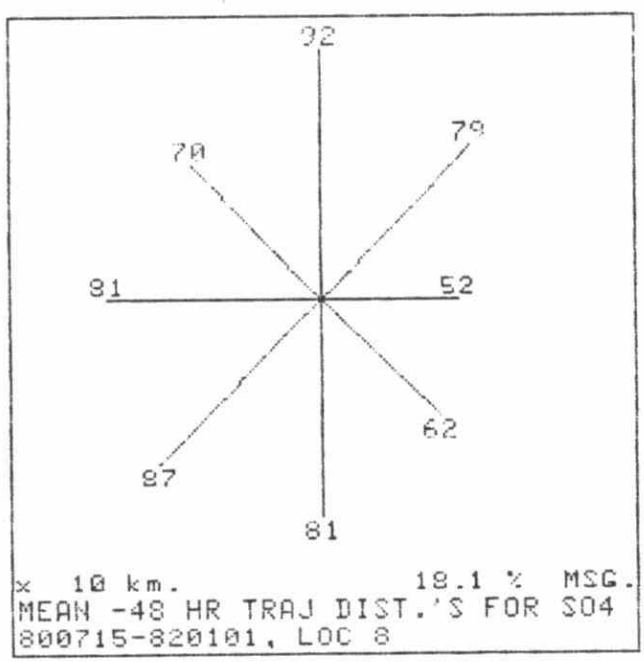
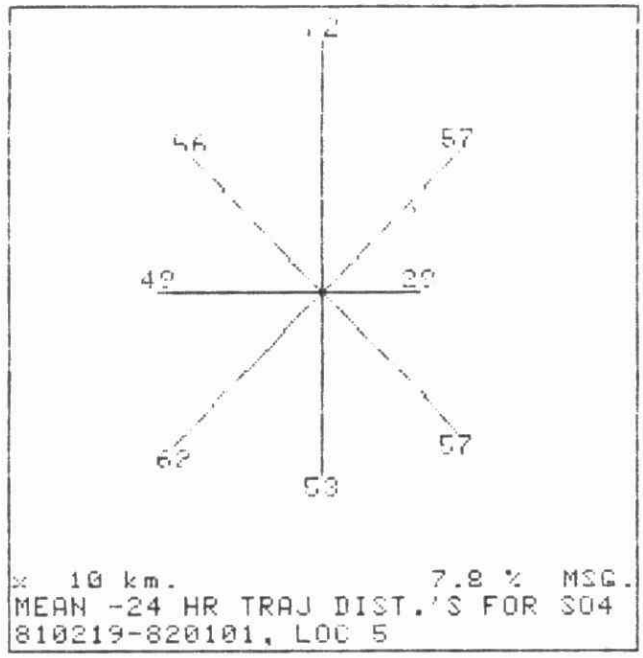
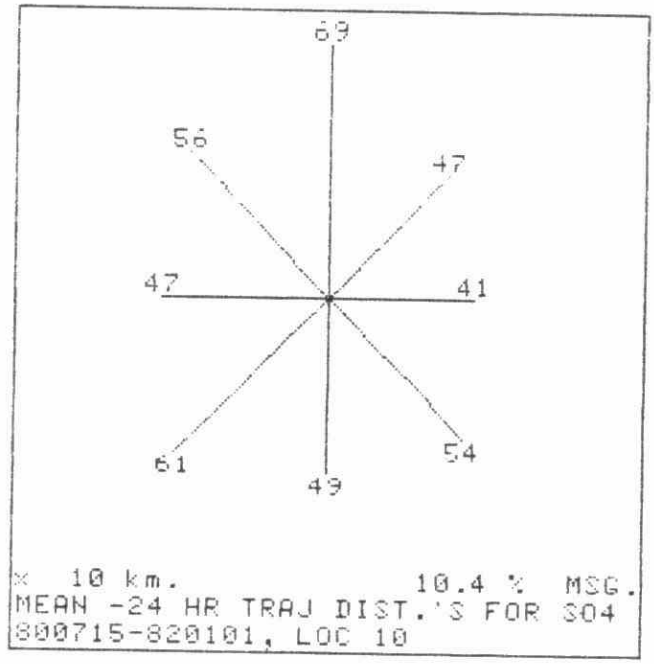

92
79
78
81
52
62
87
81
× 10 km.
18.1 % MSG.
MEAN -48 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8

Figure 19


56
57
49
39
62
57
53
× 10 km. 7.8 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
810219-820101, LOC 5


69
56
47
47
41
61
49
54
× 10 km. 10.4 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 10

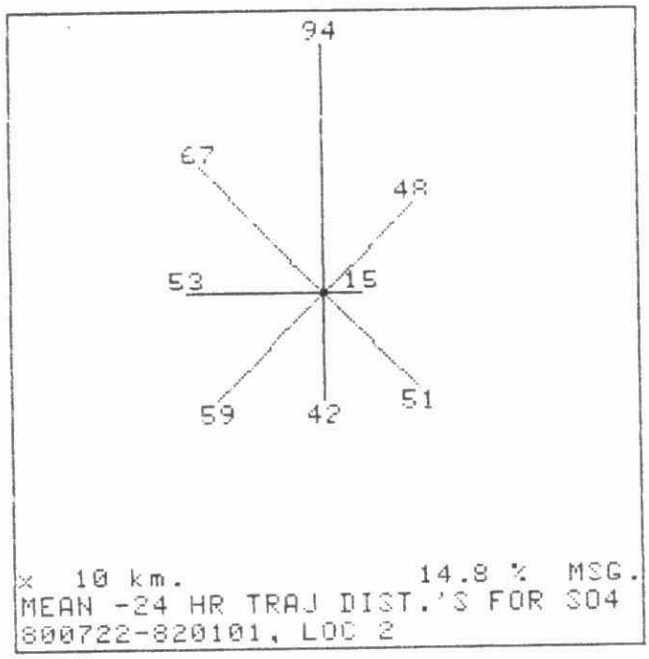
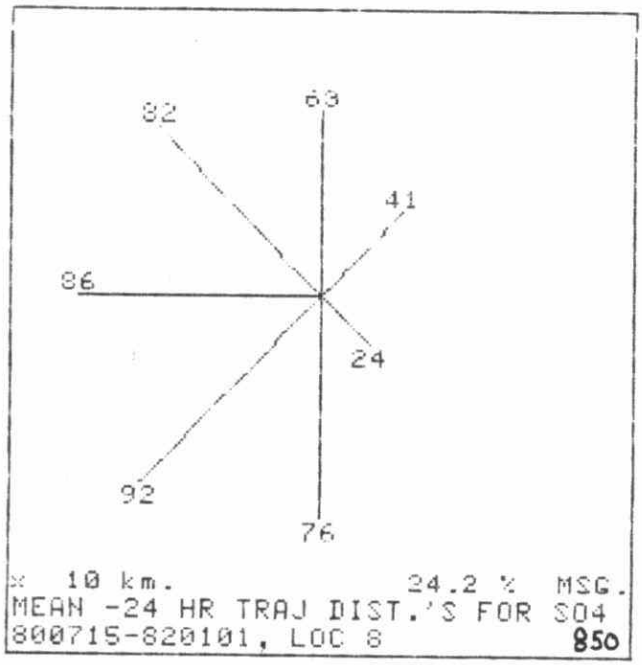
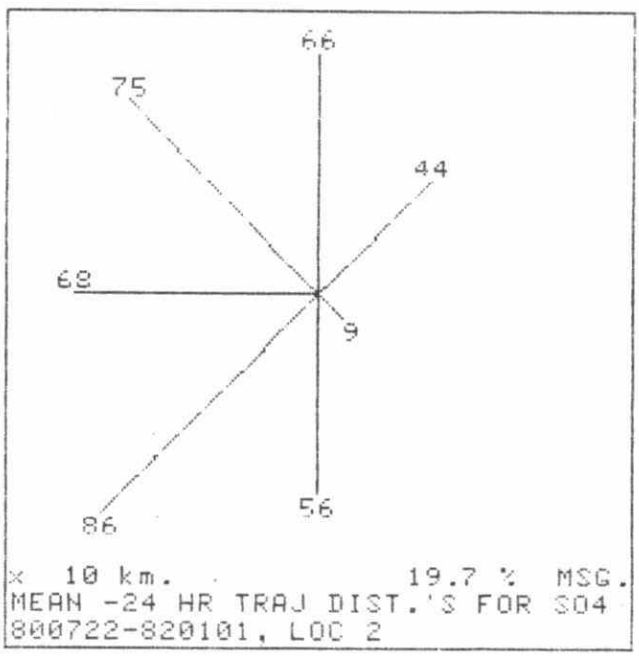

94
67
48
53
15
59
42
51
× 10 km. 14.8 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
800722-820101, LOC 2

Figure 20


82
63
41
86
24
92
76
× 10 km.
24.2 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 8
850


66
75
44
68
9
86
56
× 10 km.
19.7 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
800722-820101, LOC 2

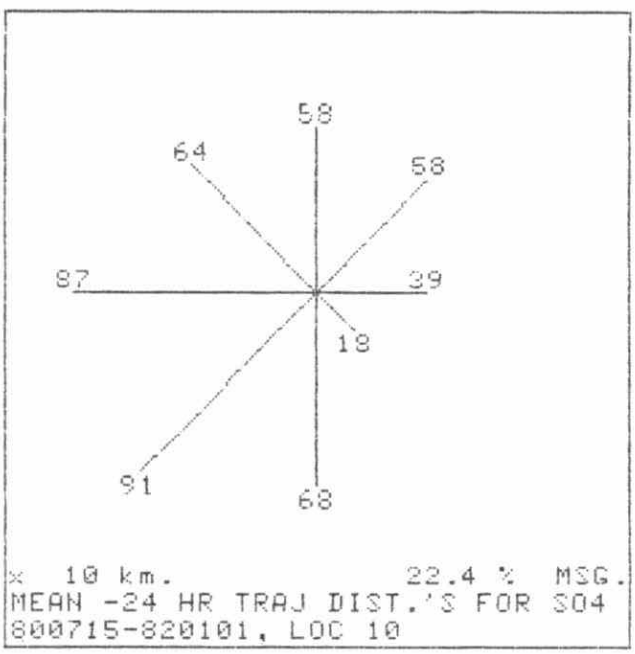
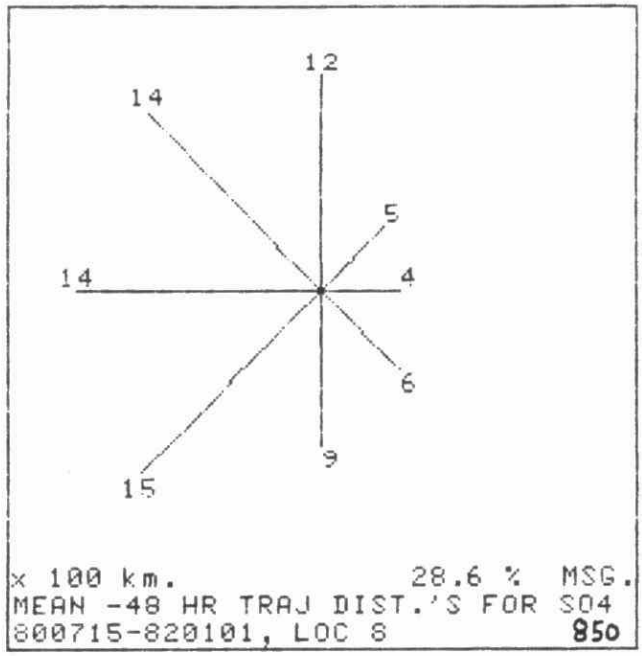
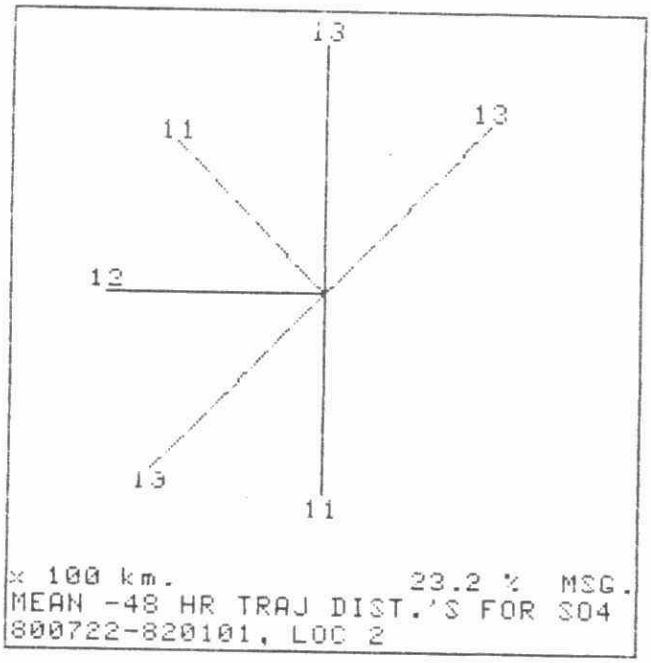
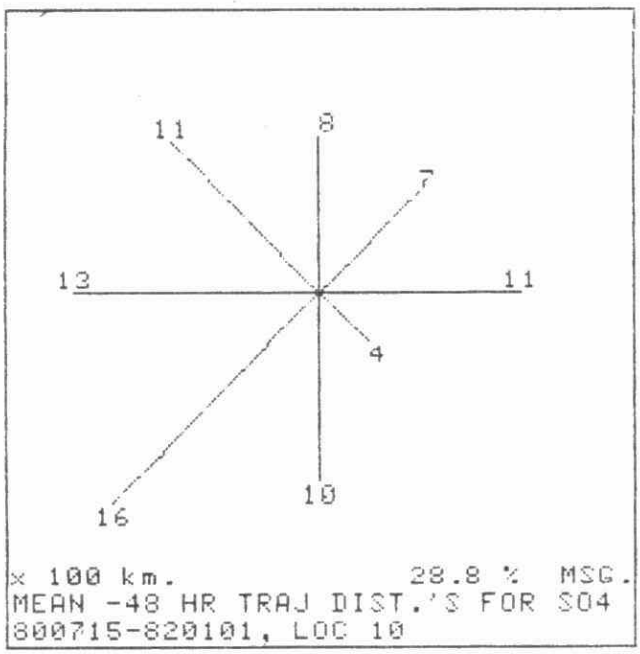

58
64
58
87
39
18
91
68
× 10 km.
22.4 % MSG.
MEAN -24 HR TRAJ DIST.'S FOR S04
800715-820101, LOC 10

Figure 21


12
14
5
14
4
6
9
15
× 100 km.
28.6 % MSG.
MEAN -48 HR TRAJ DIST.'S FOR SO4
800715-820101, LOC 8
850


13
11
13
12
13
11
× 100 km.
23.2 % MSG.
MEAN -48 HR TRAJ DIST.'S FOR SO4
800722-820101, LOC 2


11
8
7
13
11
4
10
16
× 100 km.
28.8 % MSG.
MEAN -48 HR TRAJ DIST.'S FOR SO4
800715-820101, LOC 10

QC
925.1
.O6
K95
1983